

SCHOOL SCIENCE AND MATHEMATICS

VOL. XX, No. 1

JANUARY, 1920

WHOLE NO. 165

THE REORGANIZATION OF HIGH SCHOOL SCIENCE¹.

BY GEORGE R. TWISS,

Ohio State University, Columbus, Ohio.

I am deeply sensible of the honor that has been accorded me through the invitation to address this body on a subject which in my judgment is of vital importance to the nation. However, I feel that the ideas that I might bring to the discussion of the reorganization and improvement of science instruction from the individual and local standpoint would, in large degree be coals brought to Newcastle because this association has kept itself closely in touch with the reorganization movement from the beginning, and has been one of the most important factors in starting the campaign for reorganization and carrying it forward from its inception to the present time. In proof of this I need only to recall the work in 1909-10 of members of this association in the committees on biology, earth science, physics, and chemistry of the North Central Association of Colleges and Secondary Schools, which helped revolutionize the point of view on the aims and methods of science teaching throughout the North Central territory and which helped to loosen up the requirements in science of the College Entrance Board of the Middle States and Maryland—to the far reaching influence of Dr. Mann through his work in organizing the National Commission on the Teaching of Physics, and in the country-wide study of methods and educational opinion that was carried on under his chairmanship—to the propaganda work carried on for more and better biology teaching by Caldwell, Galloway, Downing, Eichenbury and others—to the numerous studies and experiments made by members of this association and directed toward methods of teaching earth science and chemistry with closer regard to the pupils' interests and needs—to the

¹Read at the evening meeting of the Central Association of Science and Mathematics Teachers at Lake View High School, Chicago, Friday, November 28, 1919.

cordial cooperation and enthusiastic support given the Kingsley Commission on the Reorganization of Secondary Education, which in fact owes its existence not a little to some of the leaders in this body—and finally to the great work done by your official organ, **SCHOOL SCIENCE AND MATHEMATICS** in furnishing an outlet through which the leavening influence of all this activity has been spread. If all this were not sufficient I might refer to the important contributions made by members of this association in the form of text books in science for high schools, and of books and articles on the teaching of science, which have pointed out the way to a wiser choice of subject matter and better methods of teaching. Yet while all this crystallization of opinion has gone forward amongst us, and while many of your individual members have been successfully working out one or another of the principles of reorganization on which you have from time to time agreed, it is somewhat discouraging to those of us who are constantly in touch with educational work through field observation, that this leavening process has been so slow in modifying the actual practice of the great majority of science teachers. Those who attend these meetings, who read **SCHOOL SCIENCE AND MATHEMATICS**, and the *General Science Quarterly*, and keep up with the new books and papers on science teaching which are coming out from time to time would be surprised to find out how few science teachers have caught the new spirit, and how few the schools are in which science is really being reorganized or changed in any way from the subject matter and methods of twenty years ago. Unfortunately those who come here are not typical of the whole body of science teachers in the states from which they come.

The ratio of the number of science teachers with modern insight and ideals to the number of those who are conducting merely book recitations and formal laboratory practice is probably not much greater than the ratio of the number of attendants at such meetings as this to the number who stay at home, or not much greater than the ratio of the number of subscribers to **SCHOOL SCIENCE AND MATHEMATICS** to non-subscribers. This ratio as you all know is very small. We have progressed well in formulating principles for a better educational practice in science teaching; but we have done very, very little toward getting our improved ideas across to the great mass of science teachers, and inducing them to use these principles in the control of their classroom and laboratory methods. The problem

has got to the point where the greatest need lies in educational statesmanship and organized propaganda.

When we entered the great war for freedom and democracy we were brought face to face with a great and pressing need for scientific knowledge, for scientific methods of solving new problems, for the material products of applied science, and for scientific practices in speeding up production, in amounts and degrees beyond anything that ever had been thought possible or even dreamed of before the need developed.

In the general staff, in the naval and military forces, and in the industries back of them, we needed an army of trained scientists. In our colleges and high schools, in our industrial laboratories and in our government departments we had but a regiment or two, but these, scenting the battle from afar, rose up almost as one man. They quickly mobilized themselves for action and volunteered to meet their country's need. With splendid ability and devotion they organized for work, and sacrificed themselves without stint or thought of reward. Again and again they accomplished the impossible, through organized research and organized intensive training. In cooperation with the scientists of England, France and Italy, not only did they make it possible to bring the war to a swift and victorious conclusion, but they gave our people a convincing demonstration of the miracles of production that can be wrought by men trained in the methods of science when working in a compact and harmonious organization, and generously provided with funds.

A year has passed since the day of victory; and we have had time to sense the havoc that a power-drunk and money-mad nation of imperialists has wrought. For four years, millions of workers have been withdrawn from production. They have been employed in destroying one another and wiping out the material accumulations of generations and even centuries of peaceful industry, of art and of science. Civilization has been disorganized and shaken to its foundations. Strong nations are facing bankruptcy, and the menacing shadow of starvation overhangs millions of people. Strikes and violence are brewing everywhere.

In their ignorance of what the most elementary schooling in natural science and economics would have made plain to them as an open book, armies of organized workers are clogging the wheels of industry. They are slowing down production and paralyzing transportation in the face of a world scarcity of prac-

tically every product of labor that is necessary to life, while still other armies of unorganized consumers, reacting from war time self denial have plunged into an orgy of wastefulness and extravagance. *Down that road lies anarchy*, and there is only one way out. We must economize, conserve, stop waste, cut out extravagance, idleness and inefficiency of every sort and speed up the production and transportation and equitable distribution of everything that is really needed in the peaceful enjoyment of individual and collective life.

To meet this new and sinister emergency it is as plain as daylight that we need even higher and nobler types of patriotism and morality than we needed in war time. We need sincere and devoted preachers and moralists and statesmen—yes,—but we need organized scientific research and direction, and reorganized universal scientific instruction still more; for without these no efforts of moralists and statesmen can avail. If there isn't enough food and clothing and shelter to go around, the strong will take it from the weak and no preaching or moralizing or passing of laws can stop them.

These problems cannot be solved in a day nor in a year. Scientific organization and leadership we must have, to weather the storm that is upon us; but to hold the heritage of the past and build on it a better and higher civilization to which we look forward, we must have more scientific leaders. We must have more of generous and open handed support for scientific investigation, and above all more of intelligent appreciation by our whole people of the value and the need of scientific research on a scale commensurate with the greatness of our national resources and the extent and urgency of our national needs.

We must enter on a program of preparedness which shall build up an army of scientific workers to supply future needs. Not a whit less also do we need an army of trained science teachers and supervisors to rear a generation of scientifically minded laymen who shall stand as an intelligent and appreciative constituency behind this army of scientists and give them the moral and financial support that is absolutely essential to their success. The people, who hold the purse strings, who vote the taxes, and who through their representative control the state and national governments, and the universities, experiment stations, and industrial laboratories, must be made to understand; and they cannot understand so long as the language of science remains for them a foreign language, and so long as the methods of science remain hidden from them by a cloud of mystery.

So it appears that the most important problem in the reorganization of science teaching at this time is more a national problem of educational organization and administration than an individual problem of improved methods.

We must initiate a movement that will eventuate in putting all our people in possession of the most essential elementary facts of science and giving them some understanding of the value of research and the necessity of applying the scientific method to the solution of our national, state, and community problems, both urban and rural. This must be done through the education of the children in our schools. You can do almost what you will with a nation if you can control the subject matters and processes of instruction by means of which the minds of its children are directed and formed. Germany has given us a most convincing example of what can be done by organized instruction, in rearing a generation that will render unthinking obedience to a conscienceless imperialistic autocracy. We must profit by this example of autocratic thoroughness and efficiency in the accomplishment of evil ends, and turn it to account by devising methods equally thorough and efficient, but democratic and enlightened, for the accomplishment of good ends.

Therefore it seems plain that we must reorganize our school systems so as to give some scientific instruction to all children; and we must see that this is done in such a way that education rather than mere indoctrination shall result. So I think we must come out in the open and stand together for some science and nature lessons in every grade of all our elementary schools, and for some scientific instruction and training in every year of the high school.

However, it will not suffice to adopt resolutions and then turn back to our individual tasks and enterprises. If we are really to accomplish anything we must show how the thing can be done, and organize to get it done. We have been directing our efforts toward getting better instruction in the high schools, and toward developing research men in the universities, but we have overlooked the fundamental necessity of raising the general level of scientific interest and intelligence, which can be done only through science in the elementary grades. Of every one hundred children who enter our public schools approximately fifty remain to enter the eighth grade, thirty-five enter the high schools, only twenty get into the second year, only ten stick through the four years and graduate, and only five enter college.

It is of prime importance to educate our leaders; but it is of no less importance to educate the masses so that they shall know how to pick the right leaders and shall have the will to follow them. So, while we are deeply concerning our selves in giving enough and the right kind of scientific training to the thirty-five per cent who reach high school and from among whom the bulk of the leaders of the next generation will come, we must concern ourselves just as deeply with the twenty-five per cent who drop out of school before reaching the sixth grade, and the additional sixty per cent who drop out before they reach the ninth grade. These are largely those who will not be leaders, but who must be trained to recognize leadership of the right sort and follow it intelligently.

The problem of getting all the elementary pupils to study nature and science, and having them taught in such a way that their interests in scientific things may become enthusiastic and permanent is really the big problem. It will not suffice merely to give publicity to the fact that the problem exists, and is fundamental to national safety and progress.

The courses of science study must be worked out for the different grades, and written into the curriculums of all our school systems. This is a large undertaking; and it will require the cooperation of the best trained and broadest-visioned men and women now engaged in science teaching. Superintendents of schools and boards of education must be awakened to the importance of finding the solution, and must be enlisted in the enterprise. Elementary teachers who are capable of doing the teaching must be found and trained for the work. Men and women must be found who can supervise and train the teachers in service, and help them to work out lesson plans, to make teaching experiments, to test results, and to find the information that will help them in this work. These supervising experts must be able to give model lesssons, and also to pick out teachers who should be encouraged to fit themselves for becoming supervisors of science. Without such expert supervision, science in the elementary grades can never be very effective. High school teachers of science must be stimulated not only to interest promising students to go on and train themselves for scientific and technical work in fields outside the schools and colleges. They must also be on the alert to pick out interested pupils who show promise of teaching ability, and induce them to prepare themselves, in normal schools and colleges of education, to become

teachers of science in elementary and high schools, and to work up perhaps into the ranks of the supervisors and college professors. Teachers of science in the normal schools, and especially those in the colleges, must get a new slant on the problem of training students for science teaching in both the elementary and the high schools.

For if these prospective teachers are to become able to choose the kinds of scientific problems and projects that are intimately connected with the children's work and interests and knowledge both within and without the school, they must know how to organize such problems and projects for teaching purposes and how to use them successfully in the inductive approach to the important principles that are to be expounded by means of them. To do such work, these prospective teachers must be trained in a very different way from that in which most of them are now being trained.

Our analysis has now brought us down to bed rock. The whole problem of reform and evolution in science education leads back directly and inevitably to the problem of attracting young men and women of ability and enthusiasm into the work of science teaching, and training them in science and in pedagogy with methods that will habituate them to approach all their teaching problems inductively, and to study their pupils and their pupils' interests and needs, no less than they study the subjects which they are to teach.

Most college and university teachers of science do not see this teacher training problem in all its bearings. Few of them realize how far reaching their influence in promoting the spread of scientific knowledge, and appreciation for the achievements of science, would be if only they would interest themselves more in promoting, enlarging, and improving the teacher-training function within their departments. Many of them quite rightly are chiefly interested in training students for research and college teaching; and apparently they act on the belief that if one knows his subject well, and is trained for research in it, he will therefore become at once a good teacher of it. We know that this is not generally true. It is my belief that college and university teachers would attract more and better material to their research courses if they would give freshman or sophomore courses in their subjects that were designed especially to show up the achievements and the methods of science, in an interesting, even spectacular way, using many experiments, and approaching every principle

inductively, so as both to make the principle stand out very clearly and to show its applications in the solution of problems of large public interest. A parallel laboratory course should be given, which might well be optional with the student, but carry its own credit. This course should not be given for technical training in preparation for the engineering or research laboratory, but should be designed to show the method and practical utility of the science. Hence the course should consist of practical problems requiring experimental solutions, and using as far as practicable the real apparatus and appliances employed in the industries concerned.

Such a course would be popular; but that should be no discredit to the professor who gives it; for it would stimulate thought and furnish a motive for intensive study, through the human interests that it would arouse. It would serve to give the students the inductive attitude and the habit of analyzing a problem before attacking it, which is essential both to the research scientist and the teacher of young people.

Finally it would serve to attract into the department larger numbers of students, among whom would be many who would become so interested in the science that they would elect the more advanced courses which the professor so delights to give, but which he often regrets are taken by so few promising students.

This course would also serve to differentiate prospective material for high school and elementary teachers and supervisors from prospective researchers; and the former should be picked out and directed into advanced courses that would give them a broad view of the science rather than merely an intensive knowledge of limited portions of it. These prospective teachers should also be brought under the influence of a type of professor that should be represented in every large university department, namely, one whose chief interest is in the teaching side of the subject, a master not only of the subject itself but also of its pedagogy in the schools, a skilled teacher of the subject, and also an inspiring teacher of teachers. He should not forego research, but his research should be in the field of the applied psychology and sociology of his science.

College teachers are wont to complain that the students who come to them have not been taught to think. Of many of these students, this is alas too tragically true. Here are a few choice excerpts, collected by one of my friends who is a professor of zoology, from freshman examination papers.

Earthworms keep the earth holey.

It is also wonderful to know how our offspring might be so that we should not marry the wrong person if we want normal offsprings.

Symmetry is the side of earthworm toward the earth.

There are two kinds of symmetry, the one that the animal can be divided by one plane as the hydra is called diabolical. Those divided by more are called triabolical.

Two classes of nematodes are dogs and other animals such as the horse and cattle. The life history of the dog begins with the formation of the parasites. The parasites being formed and with the digestive tract completed the animal is developed.

The nematoda's one characteristic is that it can stand a strong solution of a substance and cannot be effected or gotten rid of.

The structure of animals have been traced through all the different stages—from the first and through this study and infinite research work men have come to the conclusion that God did not develop as he is at the present time but that he went through a series of changes until he reached the present stage or structure. For instance we have an intestinal system something like frogs, fish, worms, etc. We have a head like frogs, we resemble dogs and cats in that they are four legged animals only they happen to walk on structures we call hands.

These choice bits of literature, the like of which can be collected in any freshman examination in any college, prove that these pupils at least cannot think and also that they have no sense of humor. Their high school teachers stand condemned, for at least if they could not teach them to think, they might have taught them not to commit themselves to speech or writing unless they could say something that would make either good sense or really intelligent nonsense. But what about the college teachers who are responsible for the training received by these high school teachers? Do they not stand convicted of deserving a greater measure of condemnation? When their educational grand-children come home to roost have they any right to disown them?

Nothing, at least in school, tends to make thinkers out of children so much as habitual incisive analytical thinking on the part of their teachers. A teacher who carefully analyzes a problem or project before he presents it to his pupils for solution, will almost inevitably plan his questions and explanatory comments in such a way as to make the pupils analyze it, and summon their stocks of relevant knowledge to their assistance, before they attack it. Now, how are the young and inexperienced high school teachers going to be able to do this thinking and analyzing and have this consequent influence on their pupils unless they themselves have been trained in doing it? And who should be better able so to train them than their college teachers of science?

Again, you cannot get high school pupils to attack problems from the inductive stand point, or to examine the grounds for

belief in general principles before accepting them, unless their science teachers use the inductive approach in their instruction, with a definite aim toward teaching them this very thing. But how can we expect young and inexperienced high school teachers—and the great majority of them are young and inexperienced, as probably you are aware—how can we expect these high school teachers to teach inductively when nearly all of their college teachers, and nearly all their text books have taught them by methods that are almost exclusively deductive?

It is very difficult for the college teacher of science to get away in his teaching from the habit of the deductive approach. When he is working on a research problem, where he is in unexplored territory, he thinks inductively, as well as deductively, but when he is doing his ordinary routine thinking or teaching, within the familiar and well organized territory of his science, he reasons quickly by deduction, directly from well established principles to conclusions. In an efficient and well trained thinker this inevitably becomes the prevailing habit. These principles he has previously arrived at or tested inductively; and they are part of his mental tools and furniture. Not so with the student. The student can get real command of a general principle only when he has arrived at it inductively through a considerable number of concrete cases, out of which he has analyzed the general principle through his own mental processes. He must have perceived in the various concrete cases the common features which the general principle describes; else he can have no real command of the principle. Until he has arrived at it inductively, it remains an item of belief, perhaps; but it cannot be an item of knowledge. So it is of fundamental importance that his teacher shall so direct him that he must do this inductive thinking himself. The crucial test of his success is ability, first to state the principle in his own words, and then to prove his knowledge of it by citing the concrete cases from which he has abstracted it, showing in them the common conditions and consequences which have served to convince him that his statement of the general principle is true.

Now, most high school teachers do not do this unless they have served a long apprenticeship, and have learned how to do it by long experience; because their high school and college teachers have not trained them to think in this way themselves.

In my judgment, one of the most important aims of our program for the reorganization of science must be to change this

condition; and I do not believe we can do much in changing it unless we can convince the college teachers of science that the reform in methods must start with them in their training of their students—especially prospective teachers. We must get them in some way to realize how important it is that high school and elementary science should be taught right, and then we must get them to feel and understand that this whole process is in their control, because they are forming the mental habits of the persons who are to do the teaching. Then we must in some way induce them to give more earnest attention to the use of inductive methods, so as to foster in prospective teachers the inductive rather than the cock-sure habit of mind.

In some way or other also, we must get these prospective teachers trained so they will understand the vocational aspects of their sciences, and may therefore be able to give their pupils the vocational information which is so essential to their success in scientific occupations.

Now we have pushed our problem of reorganization back to the college professor of science; but even were he to do all that we might suggest, we may not stop with him. You may perhaps remember the old English recipe for cooking a hare. It begins, "First catch your hare." With the best intentions and a perfectly working teacher-training organization the college or normal school professor can do nothing toward producing more and better-trained teachers of science, unless he can get into his classes young men and women who want to become teachers, and who have the native ability to qualify.

Even when our high school teachers succeed in sending up graduates who are deeply interested in science, and anxious to prepare themselves for work in scientific pursuits, very few of these choose science teaching as a career. The reason for this is quite plain. They go into the scientific and technical occupations of the industrial world.

The salaries of teachers and professors are so low that the high schools and colleges cannot compete successfully with the industries in bidding for talented and trained young people. With few exceptions, the schools are getting the culls, and there are not even enough of these to fill the positions.

The teachers are employed by boards of education, who by now, understand this problem pretty well, and are willing to pay better salaries to get competent teachers and keep them; but the pay comes out of the public purse.

So we have gone around the vicious circle and got back again to the tax sheet and the individual pocketbook, where every question of a public nature begins and ends.

What can be done? The public purse is always lean, mainly I believe because our methods of taxation are so imperfect and inequitable that we do not succeed in getting on the duplicate all the taxable property that should be there, and at its fair valuation. Hence, the rate is always too high; and the tendency of tax-payers is always toward keeping the rate as low as possible instead of toward devising means of getting a fuller and juster valuation of all property that should be taxed.

So far as I can see, the only hope of breaking into this closed circle, is through organized publicity and agitation. The public must be educated so that they will understand the economic value of competent teaching. We need to give more attention to publicity for the science courses within the schools, so that more pupils shall want to study science and study it more enthusiastically and industriously because they shall have been made to realize its value. We need also to make this value known to the people, so they will be willing to invest more money in competent teaching.

Individual science teachers can do much, if they will, in carrying on such publicity work in their schools and local communities; but if we are to succeed in carrying out the large program that has been outlined, there must be formed a compact and powerful country-wide organization of scientific workers and teachers, to carry on the propaganda through a period of years.

Fortunately, we already have the decentralized units from which a central committee can be drawn that would function in binding all these groups together, and securing unified action.

This central committee might be made up from representatives of the National Council of Defence, the Bureau of Standards, the Bureau of Education, the Departments of Agriculture and of Commerce, the Smithsonian Institution, the American Association for the Advancement of Science, and its affiliated societies, The National Education Association, and other influential bodies such as this one, which are interested in the promotion of science and education.

Through plans worked out by the central committee, united action might be secured from these influential organizations for carrying the campaign of education into every section, state, and community.

The committee might secure articles for publication in the magazines and newspapers showing the need of science, and the fundamental importance to industry of science teaching in the production of trained scientific and technical workers. It might supply speakers to address chambers of commerce, industrial organizations, and women's club federations, and impress upon them that teaching is one of the basic factors of production, that it is not only worth while but necessary, that the industries should cheerfully tax themselves to promote scientific teaching, and that they should count it as one of the essential cost factors in production, or if not that, an investment that would yield large returns.

This committee, through the societies affiliated in it might exert a tremendous influence, through local pressure, on the boards of education and the school systems in the states and communities where their members reside. The united influence of all these societies might be brought to bear on congress in behalf of larger and more cordial support of those departments and bureaus of the national government which are doing such splendid scientific work and which would do so much more-and so much better work if they were more generously supplied with funds.

Finally, these organizations might be brought to put all their weight and all their power behind the movement for a national university at Washington which should be the clearing house and center of inspiration of all movements for the spread of knowledge and the promotion of efficiency in every national enterprise for the common good.

SCHOOL CHILDREN DEMAND METRIC SYSTEM.

The World Trade Club is daily receiving evidence as to the growing strength of public opinion throughout Britannia in favor of metric standardization. Just the other day word came from one of their co-workers in England of an interesting episode that took place during one of his lecture tours.

At Kingsbridge he spoke before a gathering of enthusiastic schoolboys from the local grammar school, telling them of what adoption of the metric units of measurement would mean to the school children of the world—how easy metrics are to learn, how simple to apply—in short, that it would lessen the necessary time spent on arithmetic by three years.

At the close of his talk, the boys unanimously adopted a resolution urging other schoolboys to go on strike with them against the British weights and measures, and demanding that only metrics be taught in the schools. These English youngsters realized the increase in efficiency, and the immense saving of time and labor obtainable through meter-liter-gram.

THE USE OF ENGLISH IN SCIENCE COURSES.

BY E. H. JOHNSON,

Kenyon College, Gambier, Ohio.

Probably every science teacher who has given any thought at all to the matter of expression has been impressed with the failure of his students to use good English when writing a report on a laboratory experiment or in an examination on a scientific subject. In the latter case, some allowance may be made for haste—the desire to cover the required amount of ground in a given time—but one cannot help wondering if similar crudities would appear in an English paper no matter how great might be the need for speed, not simply because the student expected in this case to be graded on his form of expression, and would therefore take greater pains than in a science test, but because in his literary training he had been taught to emulate the amenities of literature rather than portray faithfully the things and experiences actually found in life.

The science teacher who is desirous of giving his pupils full credit for subject matter assimilated is continually at a loss to know to what extent their written or oral expressions are indicative of their mental grasp of the points in question. Often he feels that So-and-So's recitation or examination is not a mark of his knowledge, and yet he may have no reason to question the seriousness of the student's effort. I do not refer to the purely careless type whose work is illustrated by the quotation given by James: "The birds filled the tree-tops with their morning song, making the air moist, cool and pleasant," but rather to another group of whom a recent college graduate was typical. While he was a senior, his instructor in one of the laboratory courses, having become wearied by the student's failure to use even a reasonably appropriate form of expression, and his difficulty in making a good, clear-cut report on a simple experiment, remarked that it might be a good idea to turn over some of this written work to the English Department—that possibly the instructor there might know how to remedy the difficulty. The suggestion was made partly as a jest. The student, however, taking the remark seriously, replied: "No, no, please do not do that, for I have a good grade in English."

Such a condition and the consequent conversation, probably indicate one of three things, either the English teacher was giving grades which were not deserved (which is highly improbable),

or the pupil was really careless, or, his practice work in exposition had been very limited and had dealt with subjects so remote from the phenomena of actual existence, that he was attempting a new task when he tried to form a virile expression relative to things as they are.

Not long ago, a science teacher who had been impressed with this same difficulty, mentioned the matter to one of his colleagues, a teacher of the English language. With no spirit of adverse criticism, he asked the latter if it were not possible to give more time in English work to reading and composition descriptive of actual conditions more or less of a scientific nature. He asked if time was ever spent in reading from the writings of men such as Faraday and Tyndall, men whose fame was in part due to their ability to express simple or great thoughts in the simplest of language, with a diction meaningful to an extent seldom approached in ordinary literature. He asked this English teacher if he knew about a certain text-book of selections in the English language chosen from scientific writings, and to all of these inquiries the answer was in the negative, with an added statement that these fields contained no material of interest for him—and as for the text-book—he didn't know it and he did not care to. In general, he probably spoke the truth. Perhaps he would have answered a fellow language teacher differently, for a mere matter-of-fact scientist could not possibly possess vision beyond that of the gross things immediately around him. Hence, in criticising the general use of the vehicle for the exchange of ideas, the latter was distinctly out of his proper domain.

Be that as it may, the difficulty does exist. College graduates are unable to write or speak correctly in their own native language, and their trouble seems to be greatest where directness and simplicity not only lend effectiveness, but are almost essential to correctness.

The sentence quoted from James was undoubtedly the result of a hasty attempt to produce a beautiful expression, the interest of the writer being in the artistic appearance of the sentence rather than in the significance of the thought itself. In contrast to this kind of failure is that of the student in physics, who, after a serious attempt to produce a definition, wrote: "Inertia is the force that keeps a body moving after it has stopped." It may very properly be argued that this statement also shows ignorance, but a short conversation showed that the student knew the meaning of "inertia." He had a very fair idea of what

he wanted to say, and he appreciated the absurdity of his own statement when it was pointed out to him, but even then he was unable to make much improvement in it, save to indicate by a separate statement that the word "stopped" should refer to the force and not to the motion of the body.

Again, take the following, given as a definition of a component of a force: "When two or more forces act to produce a resultant force, a component of that force is one of the two or more forces producing the resultant." We must admit that he "got there," and that his expression is not grammatically wrong, but unless the question as well as the answer were known, it would be difficult to know just what point on the circle is the desired destination.

Oral questioning immediately after the written exercise showed that this pupil also had a fairly correct idea of the meaning of the term he was trying to explain. In his English class he had a high standing. What was the trouble? This last question was also put to him, and he answered it, undoubtedly with more success than in the former case. "In our English work we don't study this sort of thing, where you've got to be so careful about what you say in order not to be all wrong. In an English paper we can say a thing in a good many different ways, and still perhaps be all right." In a science paper, however, too wide a deviation from a careful form of wording may make the definition all wrong. (This, of course, does not mean that the text should be memorized.) In other words, his training may have fitted him fairly well for the production of general expressions about almost anything, but the making of a definite statement about a detail was beyond his power.

It is not a point in the present discussion that language students should be drilled in the forming of definitions, nor in the use of technical language, but there can be little question that a masterly expression, like a creation of Rodin, has beauty because of its meaning, though it may be utterly lacking in polish.

Where can one find examples more worthy of emulation than in the writings of such men as the two physicists named above? Their form of expression was eminently successful because great ideas were conveyed in simple language that everybody could understand, and yet in language so adequate as to put to shame many of the lengthy endeavors of the literati of the ages.

Schools of oratory, law schools, theological seminaries, and more generally, all of the departments in that greater university

of world activities, know the need of men whose training has given them not simply the ability to think, but the power of persuasive expression. The world has long since learned that a master of formal logic cannot argue successfully on the great questions relating to things as they are with the man who, knowing the facts and possessing a fair vocabulary, has learned how to express his thoughts simply and definitely. This "great plainness of speech," and "sound speech that cannot be condemned"—so well appreciated by the Apostle to the Gentiles—perhaps more than any other single characteristic has given us the immortal speeches and writings of the centuries.

It may be suggested that there is a close connection between the mental power of an individual and his ability to express his thoughts definitely. This is probably true, but at the same time complete expression does not necessarily imply the power of tongue or pen to produce polished phrasing, poetic diction, or arguments impressive because of their length. A complete idea is an entity. In the terms of logic and metaphysics, it may be regarded as an actual whole and hence it exists only when all of its component parts exist, and not the least among these is the mental framing of more or less complete phrases descriptive of the fact in mind. Accordingly, a normal person should have no difficulty in stating his thought to others, if he really has the thought. And yet there are numerous examples every day of utter failure to express the ideas undoubtedly in mind. The difficulty seems to be due to insufficient training in exact expression.

Ideas on a subject, no matter how limited they may be, from the very fact of their existence, may be expressed completely if the individual is sufficiently skilled in the coordinated use of brain and tongue or pen to manipulate the tools required for the job in hand. Expertness with any kind of tool is acquired through use. Definite expression is an art in which every member of the social family should be expert.

Rather than designate the present era as a scientific or a materialistic age, I prefer to regard it as a period of transition from an inadequate order to one of which the criteria are all to be based on the continual analyses of thoughts and statements to see if they are as nearly as all possible present skill can make them in accordance with actual facts. With such standards, with the increasing interest in the world about us, in our fellows and in a common aim—whatever each of us may conceive that to be

—it cannot be denied that even as clear seeing and clear thinking are essential to this progress, these latter factors are in turn dependent on clear, definite expression if they are to become general accomplishments. To the writer, even the trifling difficulties discussed in this paper mark a vulnerable point in our educational system. It may not be "all of life to live," but there is an unquestionable relationship between life and the living of it, and the life of an age is that of its thinkers. These of necessity are largely its speakers and writers, that is, all who can express themselves adequately. This does not mean technically, nor with studied phrasing, but with that ability which may be acquired only with practice in exposition in which the subject matter, in part at least, deals with things in the world about us—things as they actually are.

Having passed through great ages of generalization, such as that in which Darwin lived, we are again living in a period of specialization, a period during which information is being gathered, definite laws are being discovered by scientists, definite problems are being investigated and solved, to furnish material, perhaps, for some greater generalization at a later time. Hence it is that, as never before, the ability to express one's thoughts on many subjects is absolutely necessary. This does not mean that he must be phenomenally versatile, it does not mean that he should dip into all lines of thought, but it does mean that he must be able to express clearly and concisely whatever thoughts he may be capable of having.

Whatever the value of a study of the past, we must not let it overshadow our appreciation of present developments in all lines of human activity. The efficiency necessary for successful existence and survival in the great competitive struggles of today requires not only definite action, but too, that definite expression of which I have been speaking. Unfortunately, this form of expression does not seem to be acquired in the average home while the child is young. Likewise it seems unattainable in the elementary schools, possibly because there the environment is so radically different from that to which the child has become accustomed at home, and also because of the great variety of tasks that are attempted. Hence it is that a greater definiteness of expression must be insisted upon in high schools and colleges, that the requisite habits in this respect may be formed before the student has passed beyond the habit-acquiring age. Inasmuch as science teachers, among others, have felt the need of

such improvement, let them commence the good work, if need be. Let them defend the argument that for the ordinary individual, the development of imaginative ability of a high productive type must be preceded by exact training in exposition involving a definite amount and a definite kind of information.

In this paper I have referred only to those instances where a really serious attempt is made at clear expression. The difficulties discussed seem to be most apparent in oral and written statements on scientific subjects, where, for complete truth's sake, concise expression is not only desirable, but absolutely essential. And I wish to emphasize the fact that what has been said is not meant as a criticism of English teachers or their work, for the work of every teacher is too exacting to permit of adverse criticism by any other. It is offered as an indicator of a real difficulty that has impressed one who is himself a teacher of science. For it is undoubtedly true that not until a correct use of the English language is demanded of every student, whether in the English classroom or in the laboratory, or in any other environment—not until then will he acquire the familiarity with his native tongue which will make him use a correct form of expression automatically and without a painful attempt. Then only can he give his thoughts so completely to the subject matter, that the resulting statement, no matter with how little effort it may be formed, may present at once the essential qualities of accuracy and the degree of elegance reasonably to be expected in a good form of speech.

GASOLINE FROM NATURAL GAS.

The recovery of gasoline from natural gas has now become a large industry, which contributes materially to the supply of motor fuels. Experiments in the conversion of natural gas to gasoline were made as early as 1903, but experiment did not give way to commercial production until about 1910. The growth of the industry since that year has been remarkable. In 1911 there were in operation 176 plants, which produced about 7,400,000 gallons of raw gasoline from natural gas. In 1917, only six years later, there were 886 plants, which produced nearly 218,000,000 gallons. Prior to 1916 most of the gasoline recovered from natural gas was derived from casing-head gas obtained from oil wells, by methods involving compression and condensation, but from year to year an increasingly large proportion of the annual output of natural-gas gasoline has been recovered by the absorption process, which has now been applied not only to "wet" gas from oil wells but also to so-called "dry" gas, which occurs independent of oil and constitutes the main supply of natural gas. Dry gas can not be profitably converted into gasoline by compression.

THE PROJECT AS A TEACHING METHOD.

BY R. W. SHARPE,

DeWitt Clinton High School, New York City.

The criticism that the subject matter taught in schools is quite largely isolated from the experiences of pupils outside the schools has led to the formulation of the project method of teaching.

The method of the project had been variously interpreted with various results—mainly unsatisfactory. Most failures result from lack of recognition (1) that projects must precede principles, (2) that principles are better understood when developed as the learner needs them, (3) that projects must be organized, so far as possible, in their natural setting.

Faulty organization of material and projects has no doubt caused most of the poor results in science and other teaching. Widespread study of the causes of faulty organization has resulted in a formulation of the term project that, if consistently carried out, will doubtless eliminate much of the unsatisfactory results toward which honest and well considered criticism is now directed.

The term project has probably been most satisfactorily defined as "A problematic act carried to completion in its natural setting." (Stevenson.) This evidently means that there must be (1) no passive reception of information by the pupils, (2) reasoning rather than memorization, (3) priority of the problem over the learning of principles, (4) a setting for the problem in the schools as near as possible to that found in life outside the schools, (5) a plan of action looking into the future which, when carried out, results in a thing accomplished.

A splendid characterization of the term project has been given by Dr. C. R. Mann¹ as "(1) A desire to understand the meaning of some fact, phenomenon, or experience. This leads to questions and problems. (2) A conviction that it is worth while and possible to obtain an understanding of the thing in question. This causes one to work with an impelling interest. (3) The gathering from books, experiences and experiments, of the needed information to answer the question in hand."

This means that the student works in much the following order: (1) A state of perplexity or of curiosity; (2) work is begun with enthusiasm because this perplexity or curiosity is the

¹Woodhull, *General Science Quarterly*, Vol. 2, p. 240, Nov., 1917.

result of a real desire for a solution; (3) once the difficulty is clearly defined the pupil's enthusiasm carries him to a solution which is almost automatic, but which in reality is (a) a process of supposition, guess, theory or hypothesis, pending further evidence, (b) reasoning out the evidence as discovered, (c) deliberate weeding out of the false so as to arrive at a conclusion, (d) application of the conclusion to other similar situations.

Quite likely most teaching is done by topics rather than by projects.² "Projects are superior to topics, in that the project originates in some question, and not in a logical arrangement of matter as found in most texts. While teaching from topics in textbooks, the teacher wrongly attempts to induce pupils to accept topics as their own projects. Topics mean a formal didactic treatment in which the teacher does all the thinking and the pupil absorbs and memorizes. Projects in their life setting lend themselves to a selection of facts according to their value or significance to the pupil. Topics furnish no such basis for selection."

Again, many teachers who recognize the value of the project method, fail to carry the method of the project to a satisfactory conclusion. This results from the attempt to cover too much ground, and the teacher attempts to hurry the pupils, forgetting that what may be very simple and obvious for the teacher may be very obscure for the pupil. The teacher, therefore, interrupts with his own thinking, and prescribes the procedure to be followed by the pupils to such an extent as to kill the student's initiative. Too much text book work brings about the same result, while a good reference book in the hands of the pupil, to be used as he feels the need for it, is quite another matter.

With the foregoing status of the term project in mind, as used in science teaching, the writer presents below some observations made of the methods used by a few writers of texts and so-called syllabi in science, with a view to discovering to what extent these writers are succeeding in teaching or organizing by the project method, as defined by our best authorities.

Let us take the subject of transportation. One text contains the following organization of subject matter.

PROJECT XVII. TRANSPORTATION.

1. Importance of transportation—Animal power compared with steam and electric power.
2. Water as a medium of transportation—Why substances float or sink.

*General Science Quarterly, Vol. 2, p. 2, Nov., 1917.

3. Archimedes principle—Specific gravity—Submarines and the floating of iron ships.
4. Steam engines—The first steam engine—The principle of the steam engine. Locomotives and steamships.
5. Steam and gas engines compared. How a gas engine works—The automobile.
6. Electric power—The parts and working of an electric motor—Electric cars and locomotives.
7. The dynamo compared with an electric motor—The principle of the dynamo.
8. Power stations.
9. Kinds of water wheels.
10. Water power and the protection of forests.

Here transportation is evidently not a project, although so named, but is really a chapter heading. An introduction is given as preparatory material properly enough, followed by some "problems" or experiments, as follows: (1) Why do some objects float in water? (2) what is the specific gravity of iron? (3) What is the principle of the steam engine? (4) What is the principle of the gas engine? (5) How does a steam engine work? (6) Study of an electric motor. (7) Study of a dynamo. (8) Visit to an electric light station.

This is followed by a number of topics amplifying the principles which motivate the giving of the didactic problems and exercises given above. This in turn is followed by a number of "individual projects."

This violates the characterization of a project in that, (1) there are few real problems at issue that are similar to those arising in real life. There is little or no natural setting. The pupils are led arbitrarily and didactically to consider (a) why objects float, (b) the specific gravity of iron, (c) the principle of the gas engine, (d) the principle of the electric motor and dynamo. There is no staging of the real problems. Certainly pupils would not naturally follow this order in attempting to solve the problems of transportation, let alone calling the general chapter heading a project. Here principles come first, followed by applications—a discarded method.

The use of a natural method of organization would much more likely result in staging the material somewhat as follows:

1. What makes boats float and submarines sink?
2. How may we transport a comparatively heavy load with a small force?
3. How may steam be used to pull heavy loads?
4. How may water wheels be used as a source of power?
5. How does electricity run a street car?
6. What makes things go?

These are likely questions that arise in the minds of pupils. There is no thought of the scientific principles involved or of

the atmosphere of the schoolroom. Of course, pupils might bring up these questions in somewhat different wording or order, to be immediately seized upon by the teacher acting as stage manager or director. Principles are ultimately arrived at, if these projects are solved to a satisfactory conclusion. Generalizations and applications naturally follow.

Another recent text presents the same matter as follows:

CHAPTER VI. TRANSPORTATION ON LAND.

1. Vehicles—Primitive vehicles—Transportation and topography.
2. Roads and vehicles—Kinds of roads—Roads and motive force.
3. Railroads—Location of grades.
4. Curves, inertia and effect—Effect of change of direction.
5. Bridges—Principle of the girder—Truss, tubular and suspension bridges.
6. Steam and the locomotive—Operation of the steam engine—Condensers.
7. Production and control of steam—Boiling temperature and high pressure—Amount of heat required—Evaporation and condensation, etc.
8. Electricity as a motive power—Motors—Generators and transformers.
9. Gasoline as a motive power—Gas engines—Dependence upon other mechanisms.

The above topics are explained and made clear by means of ample exercises which are good in themselves, but again there is no attempt to organize the material around the questions naturally arising in the minds of the pupils. That the topics are likely intended to serve as suggested projects, is evidenced by the author's statement in the preface, as follows: "The general method of the book in dealing with the topics, or projects, selected for study is broadly inductive or heuristic, etc.,," although the term project is not mentioned elsewhere in the book, so far as the writer can discover.

Another recent syllabus attacks a portion of the topic transportation, confined mainly to the source of the necessary energy, under the chapter heading "Relation of air to everyday activities," as follows:

RELATION OF AIR TO EVERYDAY ACTIVITIES.

A. Oxidation.

What makes an automobile go?

Oxidation of gasoline.

Examine diagram of an automobile engine.

Find parts corresponding to a simple cylinder—

- (a) Piston and cylinder.
- (b) Wires carrying electric current.
- (c) Place where spark is produced.
- (d) Tube carrying gasoline and air.
- (e) Carburetor.

How is the power developed by the explosion in the cylinder applied?

Toy crank shaft diagrams of gears.

Action of a 4-cycle engine.

Diagram showing,

- (1) Suction stroke.
- (2) Compression stroke.
- (3) Power stroke.
- (4) Exhaust stroke.

Why do autos have fly wheels?

Advantage of an engine having many cylinders.

How the spark is produced in an auto.

Need for a timing apparatus.

Need for arrangements for cooling engine—air and water cooled.

Need for an oiling system.

B. Burning or oxidation as a source of power.

Other substances used as fuel.

What happens in burning.

Burning a match—rusting of iron—other causes of slow oxidation.

Spontaneous combustion—explosions.

Why coal is burned.

Need for energy in human body—how supplied—need for a blood system.

Do plants breathe as animals?

C. Prevention of destructive oxidation.

D. Importance to us of the gases other than oxygen that compose the air.

The writer of this syllabus alludes to the term project only in the following sentence: "Pupils should be encouraged to work out certain *projects* or *topics* suggested by class work, each pupil to demonstrate the project to the class at a later period." Seemingly there is no attempt to distinguish between topics and projects. The term problem is frequently used, but there is little to suggest, and it is not likely that this term is used to signify a project.

The best definition of a project would exclude such a heterogeneous collection of topics as above given under the heading "Oxidation," but would be best met by organizing the material about a project in its natural setting, somewhat as follows:

PROJECT—WHAT MAKES ANYTHING Go?

Introduction or Approach.

What problems arise for solution?

Evidently something is needed, associated with heat-energy.

What else needed? Evidently a fuel, and some means of control as a stove, engine, etc.

Reasoning.

Need for a kindling temperature—example of the match.

Given fuel and a kindling temperature, is air necessary?

What portion of the air is used? Burn phosphorus.

This portion called oxygen—rest mainly nitrogen.

Oxygen supports burning or combustion.

Combustion of wood or iron wire in oxygen—example of rapid oxidation.

Rapid oxidation of gasoline in a "coffee pot cylinder."

Fuel must be in a condition to burn very rapidly, and must be confined or controlled.

Conclusion.

Demonstration by pupils, showing how rapid oxidation of a controlled fuel "makes things go." That given the proper fuel, the proper kindling temperature and air (oxygen), there is still needed a means of using the resulting energy and a means of getting rid of the wastes.

This naturally leads to a discussion of the adaptability of various fuels for different purposes, and what happens when they are burned. Problems sure to be suggested and worked out in class or by individual pupils as independent problems are:

What happens when a candle burns? When we burn a match? How to make a match? Cause of smoke? Stoves, gas ranges, lamps, etc.—rusting of iron—this called slow oxidation.

Spontaneous combustion and explosions, etc., and how prevent destructive oxidation.

Sooner or later will arise the question "What makes living things go?" This leads to a study of foods as fuel, means of getting oxygen into living bodies, and how get rid of the wastes.

The pupil is thus led to solve in some such manner as above the general import of the project "What makes things go?" or the source of power or energy, before he concerns himself with the machinery of autos, etc., necessary to handle this energy. Some pupils, indeed, may wish to work out the mechanism of an auto, but in the main he should be discouraged at this particular point as being much too difficult for the average pupil. Here it is the business of the teacher as director to see that pupils do not bite off more than they can chew, let alone digest.

The method just outlined permits of a natural setting, forces the attention upon the problems at issue, and facts and principles are learned almost unconsciously. The natural setting provides a strong motive. Finding out "What makes things go?" is far more interesting than any study of oxidation introduced as such, or "The Composition of the Air" or "The Relation of Air to Everyday Activities," or "What makes an automobile go?" if that means much attention to mechanical details.

While all projects may not be equally interesting to all pupils, yet interest in projects selected by pupils is likely to be very intense. All of this means that in place of a so-called syllabus, so commonly used as the basis of the course in science, projects form a much better basis. It is only necessary to decide what facts and principles should ultimately be mastered by the pupils, and then select groups of projects from which the pupils may make selections. These selected projects will be such that all the facts, processes and principles needed will be covered which are commonly given in the logical or systematic presentation of the subject. The project is used as the *approach* in all cases, after which it is comparatively easy to systematically summarize the entire field, if desirable.

SUMMARY.

1. Projects must precede principles.
2. Principles are better understood when unconsciously worked out as the pupils need them.
3. Projects should be offered in their natural setting, so that the situations undertaken in school are not essentially different from what they would be if undertaken in the environment outside the school.
4. The applications of the principles learned in solving such projects readily suggest themselves in solving other problematic situations.
5. Topics as given in ordinary syllabi lend themselves to no such treatment.
6. Projects encourage the pupils to do their own thinking, while the teacher acts as guide and counsellor, and provides the stage setting.
7. Even a mediocre text in the hands of the pupil, *to use when needed*, gives confidence to the weaker pupils, and assists them over many an obscure point.
8. Syllabi are as deadening to teachers as to pupils, and explain much of the poor teaching done in our science classes. Teachers are just as likely to be interested in projects as are the pupils.
9. Many suggestive projects should be outlined in a course of study, in place of a syllabus. These projects should be such as to include all the facts, principles and processes which are commonly covered in a logical or systematic presentation of the subject. The topic method is thus avoided—a method deadening alike to teachers and pupils.

DEPOSITS OF CHROMITE IN ALASKA.

Deposits of chromite have been known in Alaska for several years, but they became of economic interest only in 1917, when the high price of the ore made it possible to mine it commercially at one property. The chromite deposits of present interest in Alaska are at the southwest end of Kenai Peninsula. A description of the deposit now mined and a map showing its location are given in a short paper by J. B. Mertie, Jr., published as part of Bulletin 692-D.

HELPING THE TEACHER TEACH.

"If the teaching of agriculture is to have any permanent effect upon community life and practice, it must have a vital connection with the daily experiences of the pupils and must utilize the latest and best information available. The teacher must so organize the available subject matter that it will touch closely the pupil's life and experiences."

That is the opinion of the United States Department of Agriculture, expressed in the prefatory paragraphs of Department Circular 69, "How Teachers May Use Department Publications on the Control of Diseases and Insect Enemies of the Home Garden."

"In order to give the teacher some material assistance along these lines," continues the introduction, "leaflets indicating how teachers may make use of information contained in publications of the United States Department of Agriculture have been prepared and it is hoped that they may help to improve instruction in agriculture and kindred subjects in the schools and directly connect it with community interests. The leaflets are designed especially for teachers in elementary schools, but in many cases will be found suggestive and helpful to teachers in secondary schools and in urban as well as rural schools, depending upon the subject matter and the interests of the community served by the schools."

The circular indicates how the teacher may so closely connect the information given in the department publications with the every-day experiences of the pupils as to place the subject among the things of common interest to the average child. Copies may be had upon application to the Division of Publications, United States Department of Agriculture.

A HIGH SCHOOL COURSE IN TRADE CHEMISTRY.

By EDWIN G. PIERCE,

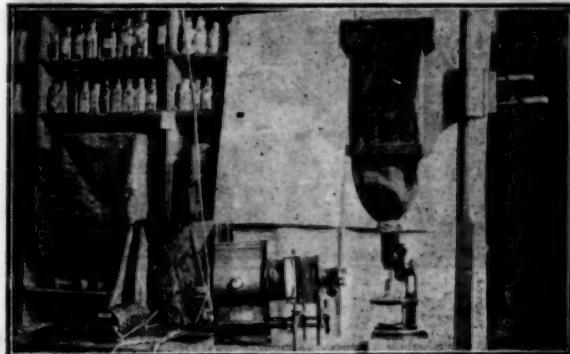
East Technical High School, Cleveland, Ohio.

The possibility of introducing chemistry as a trade course into secondary schools is a question of interest and importance.

America's rapid approach to supremacy in chemical industries gives her the splendid opportunity to take the lead in chemical education and research.

From this point of view, it is important that consideration be given to industrial as well as theoretical and descriptive chemistry in secondary schools as a means of providing the industries with skilled workmen, and laying a foundation for greater developments in higher technical education.

The number of small industries installing "works" laboratories for control purposes is increasing daily, affording more opportunities for young men and women as assistants than ever before. Clerks, stenographers, secretaries, and salesmen having some knowledge of industrial chemistry are now being more and more required.

**MICROPHOTOGRAPHY.**

It is not to be supposed that a high school course can be substituted for college training, but such a course will give those unable to go directly to college a chance to secure a start in technical work, and later to approach their higher training with more mature judgment and appreciation. It will also give the industries an opportunity to employ young people at a time of life when they are most easily trained for particular tasks, have less to *unlearn*, and have the greatest amount of energy and enthusiasm.

In addition to the educational possibilities of any trade course, such as the training in how to go about a piece of work, industrial and analytical chemistry furnish the advantage of combining mental with manual training in a manner that is unique. The machinist can see what is to be done and follow the progress of his work with the eye, touch, and tools, but the chemist, in addition to the manual operations of analysis, must constantly project himself into the realm of the invisible and unknown. Unseen atoms, molecules, and ions are his tools and materials. Being able to deal with invisible entities to produce real results of a high degree of accuracy is splendid training in working at abstract problems of any sort, and gives the student more actual faith in scientific theories.



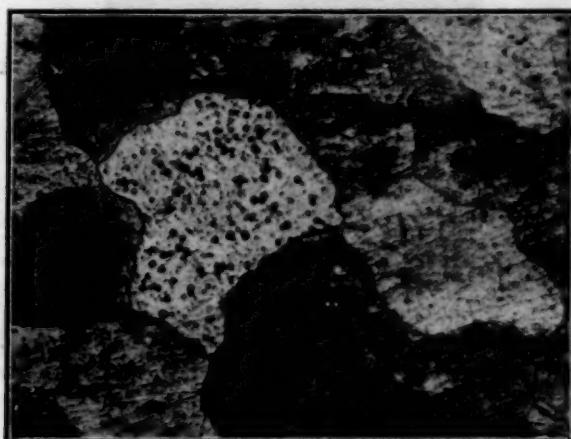
HOMEMADE OUTFIT FOR METALLOGRAPHY.

To arrange a high school course in trade chemistry which will produce training of practical value and also prove its worth as an educational factor is not an easy matter, but is entirely possible.

There are several considerations of prime importance. The instructor must have considerable actual experience as an industrial chemist. No amount of college training or summer courses can give the proper point of view nor prepare one to teach this subject understandingly. Students must have sufficient uninterrupted time in the laboratory to complete an appreciable amount of analytical work. The analyses must not drag along endlessly without results.

To the writer this last consideration is the critical point of the whole matter, and a solution of the problem was found by substituting rapid, up-to-date control methods for the antiquated exercises usually found in analytical textbooks. In a trade course, it is essential that the student learn, for example, that the "Raw Mix" in the Portland Cement industry cannot be held back from the kilns for a week while the chemist analyzes it by academic methods; it must be "jerked" within fifteen minutes but must be accurate within certain well defined limits.

These rapid methods fit admirably the necessities of a high school course. The students learn a wholesome respect for accuracy, and appreciate it all the more when a source of error



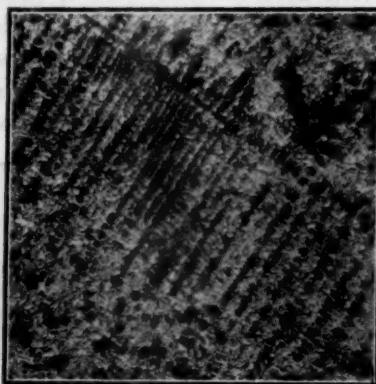
TOOL STEEL AS RECEIVED UNANNEALED, MAGNIFIED 100 TIMES

brings its result while the error is still fresh in mind. Getting results within a reasonable length of time means as much to the embryo chemist as the game on Saturday does to the football player after a week of hard scrimmage. Also, the rapid methods, when properly developed, are just as educational and involve just as important chemical considerations as the longer ones.

A great deal of work is required in preparing for such analytical work. The students must do their share of calibrating, standardizing, and other tedious jobs, but this work must be limited so that the students will not lose interest. Analyzed samples and detailed methods must be had. These are best, but not easily secured from local industries.

The majority of industrial men will not, at first, believe that high school graduates can do real chemical work, but once convinced and interested, are very willing to aid the course.

While a trade course is designed primarily for those not expecting to go directly to college, the question of its utility for college preparatory students is sure to rise, since nearly every high school student hopes to attend college sometime. The trade course in itself is a powerful stimulus toward higher education, because the student learns the value and applications of chemical theories which otherwise are only hard facts to be known at examination time and then forgotten.



DENDRITIC STRUCTURE IN LEAD ANTIMONY ALLOY,
MAGNIFIED 100 TIMES.

Having taught college chemistry and served as head of the department of chemistry in a university for some time, the writer may be permitted to express an opinion, that tracing out the chemistry of industrial processes and successful effort to secure accuracy in the analytical operations controlling them create a deeper interest in the study of chemical facts and theories and constitute a better preparation for college chemistry than all the academic lore with which the student can be stuffed. Also that all education should be preparation for real life. The writer firmly believes that the real test of the educational value of college preparatory courses should be that in case the student is unable to go to college he will still find himself as well prepared for life as four years of high school can make him. If college requirements have warped our secondary education into something that is unreal and of little value in itself, then college requirements, or our control by them, should be changed.

There is, however, the difficulty that college preparatory students have less time to devote to laboratory work. This difficulty can be met by giving these students the same recitation periods, but cutting down the number of laboratory periods

and allowing them to complete a smaller number of industrial problems.

Ohio State University has been giving full credit for the course in trade chemistry at East Technical High School, Cleveland. An outline of this course with the suggested alteration to suit college preparatory students may be of interest.

The usual one year course in high school chemistry is a sophomore subject, after which the student may elect the two-year course in trade chemistry, putting in four forty-five minute periods per day, one of which is devoted to classroom work.

OUTLINE OF COURSE IN TRADE CHEMISTRY, EAST TECHNICAL HIGH SCHOOL, CLEVELAND, OHIO.

Complete trade course						
Class	Description	Recitation period		Laboratory periods		
		45 Min.	Credit	Description	45 Min.	Credit
11 B	General Chemistry Qualitative Theory	1	5	Qualitative analysis 35 unknowns	3	7½
11 A	General Chemistry Chemistry calculations	1	5	Quantitative methods and simple analyses	3	7½
12 B	Industrial Chemistry	1	5	Rapid methods of industrial analysis	3	7½
12 A	Library and conference	1	5	Specialize on analytical methods of one industry	3	7½
			15			30

Suggested modification of trade course for college preparatory students

Suggested modification of trade course for college preparatory students						
Class	Description	Recitation period		Laboratory periods		
		45 Min.	Credit	Description	45 Min.	Credit
11 B	Same as trade course	1	5	Qualitative analysis 20 unknowns	2	5
11 A	Same as trade course	1	5	Quantitative methods and simple analyses	2	5
12 B	Same as trade course	1	5	Rapid methods of industrial analysis	2	5
12 A						
			15			15

Commenting upon this arrangement, it might seem that too much time is given to general chemistry. This could be modified, but it is felt that students can not be too carefully drilled in the fundamentals of chemistry and the repetition from a more advanced point of view clears up much that was hazy in the elementary course, and brings more clearly the realization that chemical theories are not merely abstract ideas but the real tools of the chemical profession.

In the study of industrial chemistry, no attempt is made to cover the whole field, but some half dozen fundamental industries, including those of local importance which the class may visit, and in which students may find employment, are thoroughly investigated. Fuels, water and lubricants are the first topics, then the industries in the most convenient order.

Continuity of ideas and operations is sought throughout the course. For example, one of the first exercises consists in precipitating barium sulfate from portions of a carboy of sulfuric acid made up a little stronger than fifth normal. From this, an exact fifth normal alkali is prepared and from that a fifth normal solution of nitric or hydrochloric acid; these are then compared and corrected, and further checked by running an analyzed sample of calcium carbonate or iceland spar by the acid and alkali method. Then each student runs a number of limestone samples by the Newberry method for calcium oxide and magnesium oxide, until he is able to make a determination quickly and accurately.

Iron and steel come in for an extra portion of time at East Technical. The rapid methods for silicon, sulfur, phosphorus manganese, and carbon accompany a study of the primary metallurgical processes, and field trips are made to blast-furnace, open-hearth, Bessemer, forge and foundry plants in the city. The elements of metallography are also presented with the aid of a home-made outfit which produces excellent microphotographs, and serves to give the students an idea of what can be done with that method of examination.

In addition to cement, iron and steel, other topics taken up in the trade course are—rubber, paints, oils, varnish, general chemicals, petroleum and salt. Various industrial companies have kindly furnished sets of analyzed materials and detailed descriptions of their routine methods of chemical analysis for these topics. These solutions are used for other analyses.

During the last semester it is planned for each student to

take up more intensive study and training in the industry he is most likely to follow, or, if he can secure half-day work in an industrial laboratory, he is allowed to substitute that for the four periods he would otherwise spend in the school laboratory. The latter arrangement has several advantages; it puts the student at the disposal of the employer when needed, instead of the entire class going out all at the same time to look for work; it also aids in securing cooperation between the school and the industries.

Records indicate that a majority of those completing the high school course in trade chemistry go eventually to college or higher technical schools and that practically all have been successful in chemical work.

HOLLOW BUILDING TILE GROWING IN FAVOR.

Hollow building tile, in common with other structural products, decreased in quantity and value in 1918, but its decrease in value was smaller than the decrease in the value of any other structural materials except fancy brick and enameled brick, which are minor products.

The output in 1918 was 1,964,000 tons, valued at \$12,980,000, which, when compared with that in 1917, 2,590,028 tons, valued at \$13,255,433, shows a decrease of 626,000 tons, or twenty-four per cent, in quantity, and of \$275,000, or two per cent, in value. Hollow building tile was used by the Government in large quantities in 1918 and its greatly increased use in the future seems assured, as it is not only desirable material for use in partitions and floors in large buildings in a city, but for use in dwellings, barns, silos, and other buildings in the country.

AMERICAN MANUFACTURERS DESIRE THE METRIC SYSTEM.

It is the opinion of the manufacturers of the State of Washington that metric units of measurement should be used in the United States. A referendum vote just conducted by the Manufacturers' Association of Seattle showed a 2 to 1 majority in favor of meter-liter-gram, the metric standards.

Following is a copy of the resolution sent by them to President Wilson: "In order that you may have knowledge of the interest taken by the manufacturers of Washington and sentiment with reference to changes which should be made in our system of weights and measures, we advise you at this time that the result of referendum taken among the manufacturers of this state shows that they are 2 to 1 in favor of the adoption of the meter-liter-gram or metric system."

"We believe that this system will eventually become the standard the world over and hope that you will use your good offices to establish it at the earliest possible time in the United States.—[Manufacturers' Association of Washington.]

This resolution is typical of those which are being received daily at Washington, D. C., from engineers, manufacturers, and men of every profession all over the United States.

A FEW LIVE PROJECTS IN HIGH SCHOOL MATHEMATICS.

BY FRANK M. RICH,

School 19, Paterson, New Jersey.

In the course of a friendly chat the other day, a fifteen year old boy, who attends what I take to be a fairly typical high school, voiced a criticism of his instruction in algebra and geometry, so modest and kindly and withal so sensible, that I cannot help wishing his teachers had been there to hear.

Perhaps when we get school management sufficiently democratized, so that students are free to express their views, when they have them, we shall be able to get the additional benefit of the good horse sense that these youngsters occasionally display.

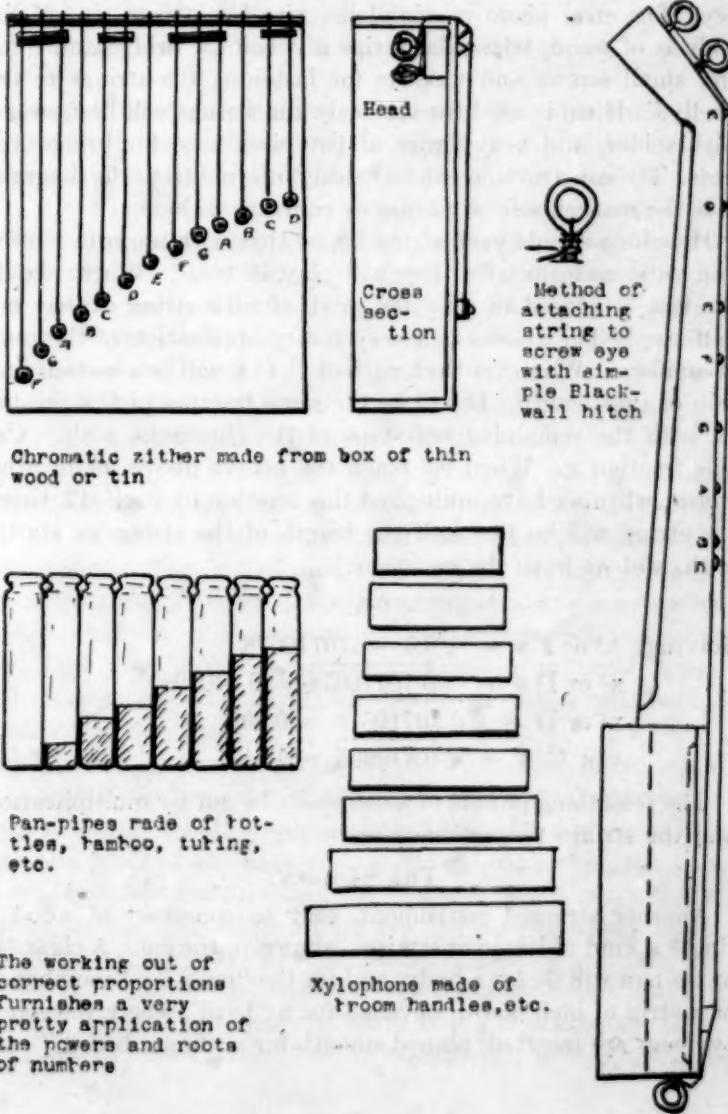
"If the teacher would only spend one day," he said, "take just one recitation period to show us some of the ways this stuff could be used by each of us in real life, I think it would be a big saving of time in the end. One period wouldn't be much, and yet it would probably be enough to answer the question that a lot of us always ask ourselves, especially when the work does not go very well, 'What's the use of all this drivel anyhow?'"

A critic less kindly and modest might have maintained that a teacher who failed to take one day and every day to show very concretely and personally what the subject matter is good for, was a pretty poor kind of instructor. For, as an ordinary selling proposition, the first step would naturally be to make the goods seem to the purchaser something eminently worth while. But the fact remains that motivation as it applies to high school mathematics for the average youth has not got very far, and a few instructors insist, like the cowboy when he saw the giraffe, "There ain't no such animal!"

However, since boosting usually gets us farther along than knocking, let me suggest a few projects that I have found the source of considerable interest to boys and girls outside the schoolroom, with the hope that they will not be found less interesting inside. One is the application of algebra in the making of home made musical instruments. The other an application of geometry in the adjustment and use of a theodolite that most high school boys and some high school girls will be able and willing to make. I do not expect that all, or even a majority of the students will be carried away with these ideas. The list is too small to meet everybody's taste. But if only one or two wish to try them, and will bring their results to class for explana-

tion and discussion, I believe that the socialization of the recitation, the injection of an element of possessive and personal interest, the extension of the method to include a very much wider range of projects to meet other interests, will in time make a decided difference in the attitude of the average student toward these subjects. Perhaps also the possible correlation with physics, mechanical drawing, manual training, music and composition will be worth consideration.

HOME MADE MUSICAL INSTRUMENTS



THE CHROMATIC ZITHER.

Almost any box of thin wood or even a square pan or rectangular oil or varnish can, cut in two, can be made into a rather sweet toned zither. By arranging the tuning pegs inside the box, and placing one fret across the end, the chromatic scale can be played with only eight strings. In addition to a can or box for the body, the materials needed will be a strip of wood for a "head" into which the keys are inserted, about $\frac{1}{2}$ by $1\frac{1}{2}$ " by the width of the instrument, medium heavy screw eyes for keys, fine steel piano or mandolin wire for strings, and if the body is of wood, triangular strips of wood for bridge and frets, and small screws and washers for fastening the strings to the "belly." If tin is used for the body the strings will be fastened with solder, and heavy wire of two sizes used for bridge and frets. The construction can be readily inferred from the diagram. It is the mathematics that mainly concerns us here.

How long should each string be, so that with uniform tension and with uniform wire they will play in tune? Where should the fret be placed to raise the pitch of each string exactly one half step? The answer is a very pretty application of the roots of numbers. Whatever the length of C, $C^{\frac{1}{12}}$ will be a certain fraction of that length. D will be the same fraction of $C^{\frac{1}{12}}$, and so on with the remaining ten steps of the chromatic scale. Call this fraction x . When we reach the octave above, or in other words, when we have multiplied this fraction by itself 12 times, the string will be just half the length of the string we started with, and we have the equation:

$$x^{12} = 0.5$$

Solving: x^6 or $F^{\frac{1}{2}} = \sqrt{0.5} = .70710678$

$$x^3 \text{ or } D^{\frac{1}{2}} = \sqrt[3]{0.70710678} = 0.840896$$

$$x^2 \text{ or } D = \sqrt[12]{0.70710678} = 0.891$$

$$x \text{ or } C^{\frac{1}{12}} = \sqrt[12]{0.840896} = 0.944$$

The remaining powers of x can easily be got by multiplication, and the strings proportioned accordingly.

THE SAMISEN.

Another stringed instrument, easy to construct of wood or tin, is a kind of banjo or samisen, shown in the cut. A cigar box or tin pan will do for a body, and for the "neck," a broomhandle or a strip of inch board, bevelled for a "head" where the screw-eye pegs are inserted, planed smooth for a "finger board," care-

fully fitted to holes in the box, the box flush with the fingerboard, and finally cut away under the "belly" to allow free vibration, and fastened with another screweye, which also serves as a "tailpiece" to hold the other end of the strings. Thumb tacks serve as "frets" on the fingerboard. A small bridge of hard wood, slightly higher than the frets, is placed near the head, and a taller one, two inches or so from the tailpiece. The upper bridge is slotted for the two strings, and the slots should be deep enough so that the strings will come near enough to the frets to be "stopped" or pressed down with the merest touch, and yet not near enough to touch when the string is played "open."

The mathematical problem, in this case, is to locate the frets, in much the same manner as the length of the zither strings was computed. The only difference is that in this case the location of the twelfth fret may be a trifle less than half way to the lower bridge, as the tension of the string is increased a little in fingering and this has a tendency to sharp the tone and would need to be offset by setting the frets slightly higher. Locate the twelfth fret by experiment and determine the difference in location due to increased tension in fretting. Subtract this difference from the theoretical location of each string.

THE XYLOPHONE OR GLOCKENSPEIL.

Bars of wood, strips of glass, lengths of pipe, etc., suspended or laid across two supports in such a way that they have some freedom of vibration give a musical tone when struck with a light mallet. The xylophone, glockenspiel, orchestra "bells" and a number of other musical instruments are constructed on this principle. Pipe, broom handles, curtain poles, window glass, hard wood moldings, in fact a variety of material of uniform cross section can be utilized for home made instruments of the xylophone type.

If the other dimensions of a vibrating bar were proportional to the length, the same law of pitch that applies to strings would apply to bars—half the length gives twice the vibrations and hence the pitch of the next octave above. But when the bars are cut from uniform material, the diameter is not proportional to the length. The smaller bars are disproportionately thick, and the thicker they are, the stiffer they are, and the more rapidly they vibrate. Hence a bar of the same thickness but half the length of another would sound more than an octave above it. In getting the dimensions, find by experiment the length which

gives the octave above and use this ratio for the value of x^{12} in the equation, and work it out as above.

PAN PIPES.

Every boy knows the musical joy to be extracted from an empty bottle, shot gun cartridge or stopped tube of any sort when blown across. A row of such tubes of the right length fastened together in a row, makes the familiar Pan-pipes, which might fit in acceptably to a collection of home made instruments. Joints of bamboo, bottles partly filled with putty, pipe or glass tubing corked at one end, etc., furnish available material for a set. The laws governing the lengths are similar except that x^{12} is considerably less than .5 for reasons connected with the curious effects of mouth pieces upon the rapidity of vibration.

THE HOME MADE TRANSIT.

Articles on elementary surveying in several popular boys' books such as The Scientific American Boy at School (Munn and Co.) The Boy Mechanic (Popular Mechanics), and the Boy Scout Manual, would seem to indicate that this sort of work makes a wide appeal, at least to boys. My experience is that girls are equally interested. Certainly there is very little in geometry to appeal to the interests of the average student apart from some concrete, utilitarian outdoor application. But most of the apparatus recommended in articles I have seen is of the crudest sort, not calculated to give results of any practical value. It is only when a class has access to a real theodolite, and learns to use it practically, for friends and neighbors, measuring the lumber in standing trees; measuring inaccessible heights and distances; laying out grounds, roads and gardens, and making accurate maps of them; locating the stars and planets from tables in the almanac; making the necessary measurements for ditches to drain land, carry off snow water, etc.; computing the labor in digging cellars, filling in grounds, blasting ledges; it is only when a class can make the old folks sit up and take notice, and do a piece of work for which somebody is much obliged, that the study begins to fill a real place in the students' lives. In every locality and on almost every piece of property, there is engineering work to be done, not important enough to hire a salaried expert, but valuable enough to be a worthy present from the class or student to the neighbor or the neighborhood that receives it.

This sort of work with a good companion or two, in the open

country is as good fun as hunting or boating or golfing, and best of all, there is the added satisfaction of doing somebody else a good turn.

Of course it will not be expected that such an instrument as we describe will do the work of a two hundred dollar transit. Neither should it be dismissed as entirely useless. It is adjusted and operated much the same as the professional instrument, and if carefully made and used, at least on coarse work, should give results that are worth while.

Before starting to make the transit, a student should look up "theodolite" in the encyclopaedia—preferably the Encyclopaedia Britannica—and read a general account of the instrument and its use. A good pocket manual—such for instance as Tracy's Plane Surveying (John Wiley and Sons)—is a necessity.

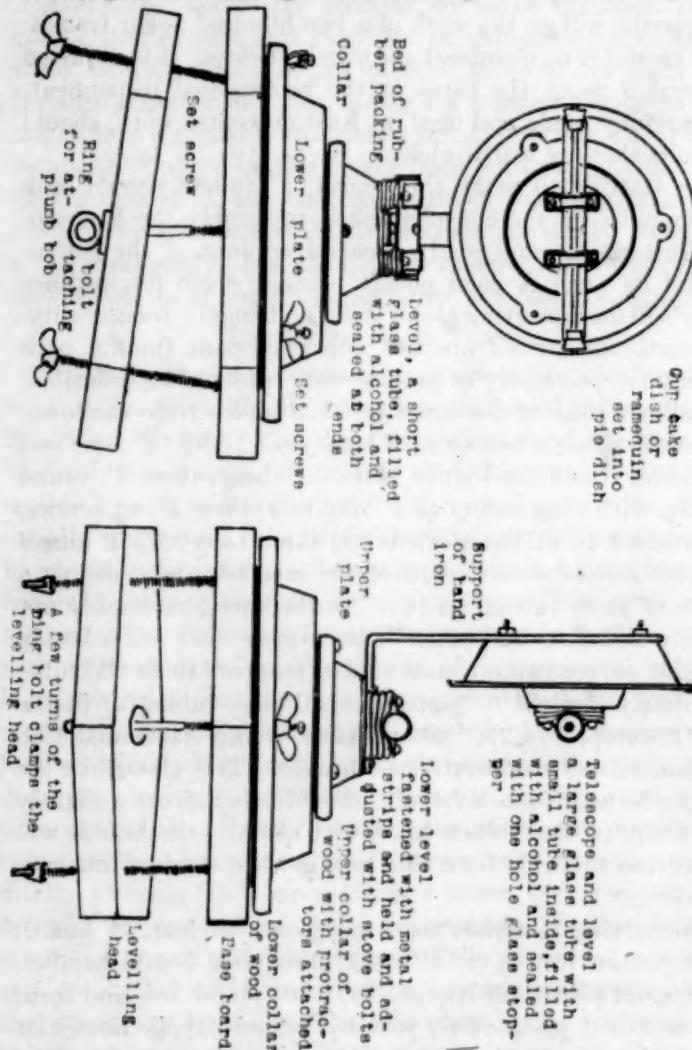
The materials needed are two cup cake pans (muffin pans or ramequins) preferably of granite ware, so as to be inflexible; two small pie pans of the same material and a trifle shallower than the cup pans; a foot or so of band iron, 1" by $\frac{1}{8}$ "; one and a half dozen round head stove bolts, $\frac{3}{4}$ " long; three 2" round head bolts with wing nuts; one 4" ring bolt; three 3" set screws; a few washers to fit the stove bolts; three heavy 3" T hinges with short screws; some strips of tin or other sheet metal; a 6" piece of glass tubing, $\frac{3}{4}$ to 1" in thickness, preferably not absolutely straight, but taken from a piece that has a barely perceptible curve; two one-hole rubber stoppers to fit the tube; an absolutely straight 6" piece of small glass tubing to fit the holes of the stopper; a $2\frac{1}{2}$ " piece of glass tubing, size immaterial, with plain rubber stoppers for both ends. This glass, like the first, is to be used for a level, and should be cut from a slightly curved strip, so that, when filled with alcohol, the bubble will not shoot too suddenly from side to side when the instrument is adjusted.

The remaining materials are some pieces of clear, 1" board; some very sound firm $\frac{1}{2}$ or $\frac{3}{8}$ " stock; three good broom handles, or other stout pieces, for tripod legs; a 10c plumb bob and cord; four pasteboard protractors, sold by school supply houses at 30c a dozen, or obtainable by taking photographic prints of 4" celluloid protractors; a quantity of rubber packing (an old hot water bottle will do) and some bits of adhesive electrician's or "friction" tape. If the hinges obtainable are not very tight, it will be better to rely on home-made hinges, made by screwing narrow blocks to the under side of the levelling head; splitting

each leg with a saw far enough so that the block can be inserted in the split, and the whole made tight by thrusting a short bolt through a tight fitting hole, placing washers at each end, and screwing the nut as tight as necessary.

HOME MADE SURVEYOR'S TRANSIT

An interesting application
of a great variety of
geometry problems



Cut the rings of thin wood and smooth them up with a file so that the hole will just fit the widest part of the cup pans, not counting the rim. Make the rings of packing of corresponding size, except that the center hole in the packing is a little smaller, so as to grip the pan a little and insure a snug fit. Work out

the hole till it is just right. When the ring is loosened a trifle, the pans should turn easily, without play; but when the rings are pressed down tight, the packing should meet the pan rim and clamp it firm.

Glue the protractors to the small rings, using the greatest care to measure with the compass and join and center the protractors perfectly. Drill snug holes, 120° apart in the rings, and corresponding holes in the pans and baseboard to which they are attached.

Saw out the hexagonal baseboard and levelling head. The upper surface of the baseboard must be absolutely true, as any curve here will throw the telescope off the true level, and greatly increase the inaccuracy of measurement. Bore a tight hole in the baseboard for the ring bolt. The hole in the lower board will have to be looser, and reamed out, so as to make a conical hole that will allow the levelling head to be tipped somewhat. The levels rest on beds of rubber packing and are held firm by hangers of sheet metal as shown in the diagrams. A little calculation will be necessary to get the band iron bored and bent so that the "telescope" can be turned completely around, just clearing the lower spirit level, and swinging in the exact axis of the instrument.

In assembling the various parts, they will have to be put together in a certain order. Screw the legs to the levelling head. Put the levelling screws in a little way. Put one of the smaller collars with its lining of rubber packing on the lower cup, and the larger collar on the large pan. Bolt the band iron support to the cup, putting a washer made of packing on the bolt between the iron and the pan, and another made of friction tape between the pan and the nut. The first washer is to allow of fine adjustment of the iron support, and with it, the upper graduated circle, so that the telescope will swing up and down in a plane exactly vertical. The band iron support, however carefully bent, will probably be slightly more or less than 90° , and slight inaccuracies can be rectified by screwing one or the other of the nuts very tightly against the packing. Both will need to be very tight, however. The packing between the pan and the nut is simply to keep the nut from turning when the screw is adjusted from above. The thinner it is the more rigid it will make the support.

Attach the short level with its deep bed of packing to the lower cup, using friction tape next to the nut as before. Do

the same with the nuts which fasten the small collar to the pan. Fasten the larger collar by screwing the 2 inch bolts firmly into the baseboard, then clamping the collar with the wing nuts.

Fasten the upper pan to the iron support; put the remaining collar over the cup, attach the long level, using less packing than with the short; fasten the upper collar; set the instrument on the levelling screws, fasten with the ring bolt, and the instrument is ready for adjustment.

ADJUSTING THE TRANSIT.

Begin with the plates and the bubble tubes for levelling the instrument. When these are in perfect adjustment, the bubble tube and the plates are parallel, and when the levelling head is truly horizontal, the bubble remains in the center of the tube whichever way the plates are turned. Our problem is to screw the bolts holding the bubble tube so that when it is level the plates are level.

All parts of a transit are adjusted by rotating them and noting the effect of each rotation. It is plain from the diagram, that a level, with one support longer than the other, might stand with its bubble in the center when the plates were out of horizontal. But the moment the plates are swung round, the bubble runs to one end. Adjust the levelling head, so that the bubble remains in the same end of the level throughout the revolution, then take up the screws on the upper end of the level till the bubble again rests in the center of the tube. Rotate, as before, and bring the plates nearer to horizontal; then take up (or let out) the proper screw to true up the level. Continue the process till the instrument is in adjustment. The level itself will need to be rotated so that the curve will be up in the center, otherwise the bubble can never be brought to rest in the proper position.

The "telescope" must be adjusted so that it moves in a plane perpendicular to the levelling plate, and parallel to the plate to which it is attached. It can be made parallel to its own plate by sighting it on a given target, then turning it over vertically, end for end (called by surveyors "plunging the telescope") and adjusting the screws, a little at a time, till the sight falls on the same point, whichever end is looked through.

The vertical plane is adjusted by levelling the transit, sighting the telescope on some approximately vertical line—the corner of a building, for instance—moving the telescope up and down

and observing how it coincides with, or cuts, the line it is sighted upon; then turning the telescope around horizontally, and sighting with the other end in the same manner. If, when reversed, the telescope traces a line that cuts the line it is sighted upon in the opposite direction, it is plain that the bolts in the support need adjustment till the lines coincide, or cut in the same direction and at the same angle, whichever end is looked through.

Having the plates and levels in good adjustment, make a mark on the upper cup opposite the 0 on both sides of the graduated circle, so that when the telescope is depressed or elevated, the line will register the angle above or below horizontal. A similar mark is needed on the lower cup.

Horizontal angles are read by turning the upper plate till the line is on 0, then turning the lower plate, upper plate and all, till the telescope is sighted on one line of the angle; then clamping the lower plate firm with the wing nuts, and turning the upper plate till the telescope rests on the other line of the angle. The mark on the plate registers the number of degrees. Considerable accuracy can be attained in reading horizontal angles by repeatedly turning the lower plate back to the first line (back sight) then clamping and turning the upper plate to the other line (fore sight) allowing the readings to add themselves on the graduated circle; then dividing the sum of the angles turned by the number of times the angle was taken, which is the average of several observations, and much more accurate than any single reading is likely to be.

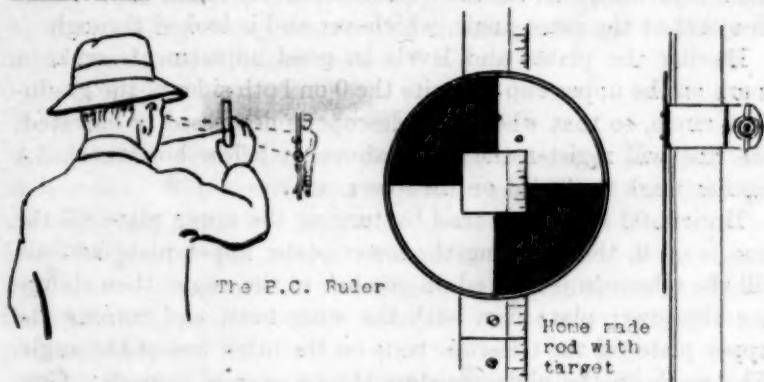
TAPE, ROD AND STADIA.

In connection with the transit, one needs a tape or chain for measuring horizontal distances, a rod for measuring vertical distances, and a stadia for estimating distances without actual measurement.

The best tape, of course, is the regular 100 ft, steel surveyors' tape, but these are expensive. The ordinary 100 foot cloth mechanics' tape will do, but they stretch more or less, and soon wear out. Even this may not be available, and the young surveyors will have to make substitutes of their own. If they can get the loan of a good steel tape to copy from, they can make a very good one out of a little over 100 feet of iron wire, 18 gauge or larger, preferably galvanized.

Take the tape and wire to a level roadway. Bend the wire into a ring at the end for a handle. Drive two stakes close together, and fasten the ring ends of both tape and wire to them.

Draw both tight with a stress of 6 pounds. At each foot, flatten the wire a little by hammering, and make a tiny hole with a centering punch or other sharp steel and label the number with Roman numerals stamped very lightly with a cold chisel. The first foot should also be divided into tenths, and possibly into hundredths.



The rod can be made by screwing a number of rulers or yardsticks to battens as long as one can reach—say seven or eight feet, marking the feet with good sized calendar numbers glued on. Surveyor's rods, like the tapes, are marked in tenths and hundredths of feet, for reason that will be appreciated especially in work with the stadia. The ordinary marks can be readily changed to decimal readings if we remember the aliquot parts of 100; $6'' = \frac{1}{2} = .50$; $2'' = \frac{1}{6} = .16\frac{2}{3}$; $1'' = 1\frac{1}{12} = .08\frac{1}{3}$ and $\frac{1}{8}''$ is practically the same as .01 of a foot.

A movable target, made of a pie tin or 6" circle of sheet metal is a convenience. In the center cut a square hole the width of the rod. Above the hole rivet a strip of metal that will encircle the rod and clamp with a bolt and wing nut, to hold the target in place. As an aid in sighting at a distance, the target should be divided into quarters, and two of the quadrants diagonally opposite painted in some conspicuous color.

The stadia in the telescope of a professional transit is an ingenious device for estimating distances without actual measurement. It depends upon the principle that the apparent diameter of an object is inversely proportional to its distance, or in other words, the farther away an object is, the more of it can be seen between lines a given distance apart and a given distance from the eye. A good substitute for wires in the telescope will be a device used by artillery officers called the battery

commander's ruler. Paste to a short piece of wood or tin, a strip of the quadrille ruled paper commonly used for graphs. Make a hole in the center of the stick and knot in a stiff string. Stretch tight and tie a knot carefully at a certain distance from the stick. If the paper is quarter inch ruled, the distance should be 25 inches. If the paper is divided into tenth inch squares 20 inches is a good length. Take the knot in the teeth, hold the stick vertically as far away from the eye as the cord will permit, and the same distance from the eye as from the teeth. A quarter inch square held 25 inches from the eye is of the same apparent height as one foot placed 100 ft. from the eye. If we sight across this simple instrument at the rod set up 100 ft. away the lines on the paper will coincide with the foot marks on the rod. If the rod is set back to 200 feet away, the squares apparently cover 2 feet on the rod; if brought up to 50 feet, the lines mark .50 ft. and so on. The distance from the eye to the rod will always be 100 times the number of feet that one space will cover. Such measurements cannot be read accurately enough for fine work, but are useful for mapping unimportant points, etc.

Having taken so much pains to construct a transit, what shall the student do with it? The answer will depend largely upon individual circumstances. One may wish to dam a brook and make a small pond; another wishes to make ditches and drain a bog; one needs to measure a flag pole for a new rope; another to know whether the old tree he purposes to cut will smash the fence in falling. One is willing to find out for a neighbor whether he can do away with his cesspool, and run a sewer to a nearby stream; another to measure and map a friend's farm. A good many will wish just to amuse themselves measuring objects from a distance, finding stars, and so on. Whether it is laying out a flower bed, or tunnelling a mountain, the transit will be found interesting and useful, and not least in interest and usefulness are the habits of scientific, accurate procedure which is the faith that literally removes the mountains.

CORRECTIONS.

The article "Biology and the War" on page 714, Nov., 1919, Vol. XIX, should have been credited to Oren E. Frazee, Normal School, Saint Cloud, Minn.

The article "Some Suggestions for a General Science Course" on page 773, Dec., 1919, was received for publication on March 8, 1917. We were not informed, until after this was printed, that the author did not wish it published. We apologize for its appearance. It is a good paper, however.

APPLIED MATHEMATICS FOR HIGH SCHOOLS.¹

BY EUGENE H. BARKER,

Polytechnic High School, Los Angeles, California.

For a number of years there has been a very manifest feeling of unrest and dissatisfaction among teachers of high school mathematics concerning the content of the course as now organized. From time immemorial the first year has been given over to a treatment of the traditional algebra in the traditional way, with its multiplicity of pestiferous and uninteresting so-called "problems," all too artfully and villainously contrived, but having absolutely no connection with the child's past experience, present interest or future prospects.

This is customarily followed in the second year by a pains-taking study of a collection of formal proofs of theorems in geometry, interesting to the mathematician and the logician, but a dreadful task for the uninformed novitiate.

While this two-year treatment of algebra and geometry has its merits, may there not be some selection, some eliminations, some re-arrangement of material possible, which, while just as much educational in value, can be turned to practical account in the student's daily life?

For time out of mind it has been the custom at learned conventions of pedagogical highbrows to deprecate in a vague sort of way the lack of a proper coordination between the schoolroom lesson and the practical problem as it arises in the household, on the farm, in the shop, or at the office.

It is not my present purpose to discuss the *desirability* of a course in applied mathematics, for I think we are all agreed that such a Course *is* desirable. Nor shall I indulge in vague generalities or pedagogic theories. Instead, I shall cite actual specific problems which possess at the same time interest for the student and have a practical value.

These six things a practical course in applied mathematics must compass; namely,

1. An adequate treatment of the fundamental operations of arithmetic with proper attention to modern methods of performing these operations.
2. The cultivation of the ability to judge a computed result as to its *reasonableness*.
3. A sufficient acquaintance with the symbols of algebra

¹Delivered before the Mathematics Section of the California Teachers Association, at Berkeley, October 15, 1919.

and of algebraic operations to enable the student to interpret and apply simple algebraic formulas.

4. A sufficient knowledge of geometry to enable the student to compute the areas and volumes of the commonly occurring geometric figures.

5. Some facility in the use of tables.

6. The ability to read a graph.

The field of graphical representation affords wonderful opportunities and possibilities and should be treated at considerable length.

It frequently happens that an idea can be expressed very much more clearly and briefly by a drawing than by words. Thus, the idea of a square is conveyed instantly by a picture of a square, \square . The drawing or diagram is called a graphical representation. Many illustrations of this sort will be doubtless already familiar to the student. Tally marks, $\cancel{\cancel{\cancel{\cancel{\cancel{X}}}}}$ the indication of the hours on the clock-face by the numerals I, II, III, IIII, etc., the determination of the pitch of a note by its location on the musical staff, , the crescendo sign,  diminuendo, , etc., are all graphic in character, as also are the indication of direction by an arrow,  the north and south line, , conventional signs used in map drawing, like  for railroad,  for grass, astronomical symbols such as \oplus for earth, \odot for moon, the symbols of geometry. \triangle for triangle, \odot for circle, and the like.

A geographical map is an example of line representation wherein distances are plotted to some convenient scale. In every case the scale used will depend upon the amount of territory to be shown and on the desired size of the map itself.

Line representation is the basis of drawing and of all mechanical work. The floor-plan of a house, for example, and its elevation, are graphical representations of the location of walls, doorways, windows, etc.

Such data as the valuation of exports, imports, increase in population, relative lengths of rivers, heights of mountains, changes in temperature, amounts of rainfall, variations in the price of food-stuffs, and the like, can be presented much more effectively by means of diagrams than by columns of figures.

A relation like that which exists between the speed of a vehicle and the time consumed in traveling one mile is best shown diagrammatically.

Graphic diagrams are of a great variety of forms, and in determining upon the scheme of representation to be used in a particular case, the student should select that type which will set forth in the most telling fashion the essential facts of the data to be presented.

Abundance of material suitable for graphic representation can be found in such publications as the *Statistician's Year-book*, *World Almanac*, *Tribune Almanac*, *Scientific American Reference Book*, and any geographical-statistical atlas. Much material of this kind can usually be obtained from the local Chamber of Commerce, Bureau of Mines, Development Board, the newspaper offices and the banks. A great variety of types of graphical representation will be found in various magazines, especially those devoted to engineering and construction work. Indeed, scarcely a book or technical article is written these days wherein the author does not have recourse to pictorial charts or diagrams.

The use of tables is a subject to which especial attention should be given. There are certain calculations which occur so frequently that to save time and labor their results have been tabulated. For example, the circumferences and areas of circles of various diameters, the square roots of numbers, the decimal equivalents of common fractions, etc., have all been arranged in tabular form in much the same way that multiplication tables are arranged, or as railroad time-tables are arranged. These tables are not ordinarily memorized as the multiplication table is, but are consulted or referred to each time need arises for a particular result.

For example, if one wants the square root of 20, he does not actually extract the square root but refers to a table of square roots and finds it to be 4.4721. Or if he desires to know the area of a circle whose diameter is 50, he refers to a table of areas of circles and finds it to be 1963.5. Or again, if he desires to know the interest on \$350 for two years and six months at eight per cent, he refers to an interest table and reads his answer instantly, \$70.

Just what tables one needs most, depends upon one's occupation. The machinist has use for tables of decimal equivalents of common fractions, tables of cutting speeds, etc. Draughtsmen and designers use tables of strengths and weights of various materials, standard proportions of machine parts, etc. The actuary uses mortality tables, the banker, interest tables, the

merchant, discount tables, the electrician, wiring tables, etc. The professional computer has need for all of these and many more.

There are certain mathematical tables, however, which are of general value, whatever one's occupation. Among these are tables of squares, cubes, square roots, cube roots, decimal equivalents of fractions, and logarithms of numbers. The table in most common use is the multiplication table.

It is a simple matter to familiarize students with the commonly occurring formulas of mechanics.

What boy in the class will not manifest an interest in the solution of such a problem as the following?

From the equations $s = \frac{1}{2} gt^2$ and $v = gt$, find the time it takes a pole-vaulter to reach the ground after he has cleared the bar at 13 ft. $2\frac{1}{2}$ in., and find the velocity with which he hits the ground on descending.

A knowledge of ratio is essential to a proper understanding of the mathematics of industrial and mechanical pursuits. For example, mechanical advantage is defined in terms of ratio; specific gravity is defined in terms of ratio, and such expressions as gear ratio, and coefficient of expansion are of frequent occurrence.

There is no lack of suitable material for class-room work, suitable in point of interest and suitable in point of practical applicability. In the field of mechanics there are such problems as these, for example:

If a spindle tapers one sixteenth of an inch to the inch, what is the amount of taper per foot?

If a mechanically operated hack-saw makes 90 strokes per minute, what is the number per hour?

The driving pulley on a shaft is 42 inches in diameter, and makes 200 revolutions per minute. How many revolutions per minute will the driven pulley make if its diameter is 3 feet?

If steel expands 0.000007 of its length for each degree increase in temperature (Fahrenheit), how much will a 30 ft. steel rail increase in length when heated from 32 to 130?

Given the materials for a paving mixture as follows: 1 part of cement; 3 parts of sand; 6 parts of crushed rock; where a sack of cement is equivalent to about 1.3 cubic feet and a wheel-barrow load of material to about 4 cubic feet. If all the materials necessary for the mixture are to be dumped every 30 feet, how much of each material should be dumped at each place, if the

street is 40 feet wide, and the paving mixture is to be laid 5 inches deep?

Who will question the practical nature of the problem just cited? Who will say that it is not concrete?

In closing I submit an even dozen other typical problems from a variety of fields, commercial, industrial, agricultural, mechanical, and invite your attention to their practical character.

1. If a map is drawn on a scale of 100 miles to $\frac{3}{4}$ of an inch, what distance is represented on the map by $\frac{5}{16}$ of an inch?

2. If 400 cubic feet of stacked hay weighs one ton, find the weight of a stack 22 feet by 40 feet by 24 feet?

3. A certain school district voted \$15,000 to erect a new schoolhouse. The assessed valuation of the property in the district was \$750,000. Find the rate of taxation.

4. Two pulleys have their centers 20 feet apart; their diameters are 26 inches and 24 inches. What length of belt is required to connect them?

5. At 30 cents per running foot, what is the cost of a roll of belting of 16 turns, with outside diameter 2 feet; inside diameter 20 inches?

6. If the standard 150 yard target has a bullseye 8 inches in diameter, what should be the diameter of a bullseye which will appear the same size at 25 yards?

7. Prepare a diagram setting forth graphically the following facts. Of the persons who have attained sufficient distinction to be listed in "Who's Who in America," 71% were college trained; 16% had high school training; 9% stopped after the grammar school; 3.8% were prepared by private tutors, and .2% are self made.

8. If the weight of oak ashes is .03 of the weight of the wood burned, and the weight of carbonate of potash contained in the ashes is .065 of the weight of the ashes, how many pounds of carbonate of potash are there in the ashes of 1 cord of oak, if stacked oak wood weighs 2 tons per cord?

9. A shaft has upon it two pulleys, each 8 inches in diameter. The speed of the shaft is 400 revolutions per minute. What must be the sizes of the pulleys of two machines, if when belted to the shaft one of them has a speed of 300 revolutions per minute and the other of 900?

10. A sugar factory consumes on an average 3,000 tons of beets per day. If 75 per cent of the sugar in the beet is extracted how many tons of sugar are produced per day from beets containing 15 per cent of sugar?

11. An automobile is bought for \$1,000, run for 4 years, and sold for \$750. During that time the cost of gasoline and oil average \$.75 a day; repairs, including tire expense, amounted to about \$25 a month; license \$15 a year, and insurance \$25 a year. What did the automobile cost per day?

And in order that I may leave a good taste in your mouth, I submit, as No. 12, this problem:

12. If a circular cake 7 inches in diameter and $3\frac{1}{2}$ inches high, sells for 50 cents, what will be the probable price of the same kind of cake 16 inches in diameter and 8 inches high?

Surely there is no lack of material for practical problems and the time is ripe for reform. My prediction is this, that inevitably, and soon, the traditional high school algebra and geometry will give way to a single course in applied mathematics.

PLATINUM-BEARING GOLD PLACERS OF THE KAHILITNA VALLEY.

The Kahiltna Valley, Alaska, including the basins of Cache and Peters creeks, was visited in the fall of 1917 by J. B. Mertie, Jr., whose report on his work has just been published in the Survey's Bulletin 692-D. Mr. Mertie gives a geologic sketch map of the region, describes its geography and geology, and presents an account of its mineral resources, which includes descriptions of the placers on many creeks. Though gold is the only mineral thus far recovered in commercial quantities the placers have yielded small quantities of other valuable minerals, which include platinum and ores of tin and tungsten.

DETERMINATION OF THE BROCARD POINTS.

By J. CARL KAMPLAIN.

Student, Crane Junior College, Chicago.

I have read the methods of determining the Brocard points of a triangle which were published in SCHOOL SCIENCE AND MATHEMATICS for May, 1918, as solutions of problem 555. I should like to submit the following solution which I think you will find simpler than any which were published at that time. As far as I know this method of construction has never been published.

In $\triangle ABC$, to find P_1 and P_2 such that $\angle CAP_1$ (ACP_1) = $\angle BCP_1$ (CBP_1) = $\angle ABP_1$ (BAP_1).

Construction for P_1 :

Draw Cw and Az intersecting at D , and By intersecting Cw at E , so that $\angle ACw = \angle C - \angle CAz$ and $\angle CBz = \angle B - \angle BCw$. P_1 , the point of intersection within the triangle of the circles circumscribed about triangles ACD and BCE , respectively, is the point required.

Proof:

By principles of elementary geometry, $\angle AP_1C = \angle ADC = 180^\circ - \angle C$, and $\angle CP_1B = 180^\circ - \angle B$. Therefore $\angle AP_1B = 180^\circ - \angle A$.

Therefore, $\angle P_1CB = C - [180^\circ - \angle P_1AC - (180^\circ - C)] = \angle P_1AC$.

Likewise $\angle P_1BA = \angle P_1CB = \angle P_1AC$.

Similarly for P_2 .

INTRODUCTORY COURSES IN BOTANY III.

BY BRADLEY M. DAVIS,

*University of Michigan, Ann Arbor.**(Continued from December, 1919.)*

OUTLINE No. 7.

A High School Course.

1. Gross morphology of any common plant.
2. Rapid survey of the chief groups of the plant kingdom to develop the idea of classification. Gather types in the school garden or vicinity, or have types growing in the laboratory. Division, class, order, family, genus and species.
3. Comparative study of bean and corn. Plants, seeds and seedlings. Life cycle.
4. Study of protoplasm in plant and animal cell. Spirogyra, Amoeba, Elodea, onion skin or other simple tissue.
5. Careful study of the morphology and physiology of a seed plant. Emphasize the relations between structure and function.
6. The leaf. Activities discovered by experiment, structure then studied.
7. The root. Structure and function, osmosis, capillary action, root pressure, relation to soil. Conditions necessary for health, air, water, physical conditions of soil.
8. Stems. Types and function, some study of comparative structure.
9. Buds. Structure and functions.
10. Flowers. Study of a few available types. Adaptations, pollination.
11. Fruits. Principal forms, structure and development, food relations.
12. Seeds. Types of structure, food storage.
13. Seedlings. History and conditions of development.
14. Reproduction. General considerations based on material studied. Asexual methods compared with sexual reproduction.
15. Plant breeding. Methods employed and results of economic value.
16. The weed problem. The struggle for existence, variation, survival, adaptations. Principles of organic evolution.
17. Plants of economic value. Emphasize the dependence of animal and human life upon plants, the dependence of the city upon the country.
18. Bacteria and other fungi. Study of the structure and life habits of a few forms. Relation to decay, the soil, animal and plant diseases.
19. Work of state and federal departments of agriculture.
20. Type studies to illustrate plant evolution if the length of course permits.
21. Plant communities. Field studies if time permits and if seasons and school conditions render practicable.

"My experience is that pupils are especially interested in plant activities and in structure studies showing adaptations. In a short course subjects 1-19 inclusive should be taken. Some of these topics may be dealt with lightly but 4-14, 16 and 18 should be the backbone of any course."

"In high school work careful study and selection of apparatus is necessary. In most cases botany precedes physics and chemistry and therefore simple lessons on oxygen, carbon dioxide, composition of air, soil, water, etc., are necessary before experiments on leaf activities are started. In every case preliminary lessons by the teacher must prepare the pupil to perform experiments or to understand demonstrations."

OUTLINE NO. 8.

A half-year course, ten hours a week, or a twelve weeks course fifteen hours a week.

1. Introductory. Definition and scope of the science. Why a study of plants is important.
2. Parts of a seed plant (chiefly a review of what has been learned in Nature Study in the lower schools).
3. The cell as the unit of structure and function. Protoplasm.
4. Vegetative functions of a seed plant, including the structure of the organs involved. (a) Transpiration. (b) Absorption of water. (c) Passage of liquids through the plant. (d) Nutrition, including gaseous exchange; the elaboration, translocation, storage, digestion, and assimilation of carbohydrates and proteins; secretion and the economic value of plant secretions (briefly); theories of crop rotation.
5. Fermentation and the nature and work of enzymes.
6. Respiration.
7. Growth.
8. Adjustment to environment.
9. Life history of the fern with discussion of methods of reproduction, alternation of generations, life cycle, inheritance (briefly), struggle and survival.
10. Life history of moss and liverwort.
11. Life history of some algal types.
12. Life history of some fungal types.
13. Economic importance of fungi, including plant diseases.
14. Saprophytism and symbiosis.
15. Sex.
16. Calamities and lycopods (briefly or optional).
17. Life histories of seed plants. Cycad. Pine. Angiosperm.
18. Plant families. Representative types, chosen with regard to their economic importance.
19. Theories of evolution, especially Darwinism and the Mutation theory.
20. Heredity with special emphasis on Mendelism and its practical bearings.
21. The evolution of plants through geological time (briefly or optional).

"Outside of technical schools, introductory courses should be planned, not primarily as introductory to more advanced courses in botany, nor wholly as a preparatory study for agricultural students, but as introducing the student to the nature of the subject, its materials, methods, aims, broader generalizations, history, unsolved problems, and its bearing on the student's own every day life; and especially on the supposition that the majority of the class may never take advanced courses. Emphasis, therefore, should be placed on the larger conceptions, broad general principles, and philosophical aspects of the subject. Relating the subject to the student's own life should be done chiefly with reference to its economic or commercial aspects, and especially to its cultural aspects."

"It should always be kept in mind that the course is in botany and not in horticulture, agriculture, plant pathology, market gardening, commerce, or in any other pure or applied science or art. This point of view is absolutely essential in consideration

of the best interests of the pupil and of any subsequent courses founded upon or closely related to botanical science. The aim of the course should be to give the student (1) a general survey of the science in its established departments, (2) acquaintance with general principles and problems, (3) introduction to the methods of science, and (4) preparation for courses in related applied sciences, such as horticulture, plant pathology, plant breeding, forestry, medicine, pharmacognosy, etc. It is, of course, taken for granted that class discussions, lectures, and laboratory work will be supplemented by assigned readings in the adopted text or other books."

OUTLINE NO. 9.

A half-year college course, eighteen weeks, six hours a week.

1. Introductory. History and importance of botany. Consideration of the seed plant as a whole.
2. The soil and its major constituents, with emphasis on the relations between plant and soil.
3. The principles of diffusion and osmosis. The intake of water and salts by the plant. The structure and function of root hairs.
4. The external and internal structure of roots and a study of the various functions assumed by roots.
5. Transpiration, with emphasis on the factors governing it and the importance of the process to the plant.
6. Photosynthesis. Its raw materials, apparatus, energy, and products.
7. The structure of the leaf, gross and microscopic, with particular emphasis on the function of each part.
8. Digestion and assimilation, with study of the main food types—carbohydrates, fats, proteins—and their importance to the plant. Enzyme action.
9. Respiration and fermentation, with emphasis on a study of the energy relations in the plant.
10. The stem of typical dicotyledonous and monocotyledonous plants, its structure and the part played by each tissue in the economy of the plant.
11. Wood, its structure and characteristics.
12. Growth as illustrated by a study of (a) some terminal growing point such as the onion root tip, and (b) the cambium, with an attempt to make the student visualize clearly the process of growth in plants.
13. The process of reproduction. The flower, its structures and their functions.
14. The fruit, seed and seedling.
15. The algae and fungi.
16. The mosses and ferns.
17. Principles of classification as brought out by actual work in plant identification by means of manual and keys.
18. Principles of inheritance. The theory of organic evolution.

"The primary object of this course is not to amass in the student's mind a wealth of knowledge relating to the whole plant kingdom and the various subdivisions of botanical science, but through the study of some typical seed plants, to enable him to appreciate the plant as a living organism. Structure and function are obviously so nearly interrelated that they are taken up essentially together, though the primary attack always

emphasizes function rather than the structural basis. Type studies, life histories, and homologies in the vegetative and reproductive structures of the various plant groups are largely avoided, though a very brief survey of the plant kingdom is made to enable the student to get a true perspective and to serve as a basis for a short consideration of the principles of evolution and classification."

OUTLINE NO. 10.

A twelve-weeks college course, three hours a day for five days a week. Given two days a week, the course would require a full year, or with four days a week it could be covered in a half-year. The three hour class period is divided between lecture and laboratory work as the subject requires. Each number in the outline represents a three-hour period.

I. STRUCTURE AND FUNCTIONS OF TISSUES.

First week.

1. External characters of stems, roots, and leaves. Leaf arrangement, especially in relation to light.
2. The cell. Cell wall, protoplasm, nucleus, chloroplasts, and vacuole. Function of chloroplasts with physiological experiments to show the products of photosynthesis.
3. Epidermis. Structure, with experiments to demonstrate its function.
4. Leaf tissues. A study from leaf sections of the structure and functions of its various parts. Experiment to show transpiration.
5. Parenchyma and collenchyma, and their functions.

Second week.

1. Tracheary tissue and tracheids, and their functions.
2. Wood and bast fibers, and their functions.
3. Sieve tissue and its function. Experiments to demonstrate some functions of vascular tissue.
4. Study of a woody stem to show arrangement of tissues, and annular rings.
5. Types of vascular bundles in stems, the open and closed collateral bundle, concentric and amphivasal bundles.

Third week.

1. Seed germination. The root cap and root-hairs.
2. The radial bundle and the structure of the young root. Experiments to demonstrate osmosis and root exertion.
3. Food storage in stems, roots, and fruits.
4. Starch and aleurone. Experiment to show digestion of starch in seeds.
5. Meristem and mitosis.

II. REPRODUCTION.

Fourth week.

1. External features of the gametophyte and sporophyte of the fern. The sporophyll, sorus, sporangium, and spore.
2. The archegone and antherid of the fern.
3. Fertilization and the development of the embryo of the fern.
4. Microsporophyll, microsporangium, and microspore of the pine.
5. Megasporophyll, megasporangium, and megaspore of the pine.

Fifth week.

1. Male and female gametophytes of the pine.
2. Fertilization, and the development of the embryo of the pine. Significance of heterospory.
3. Microsporophyll, microsporangium, and microspore of a flowering plant.
4. Megasporophyll, megasporangium, and megaspore of a flowering plant.
5. Male and female gametophytes of a flowering plant.

Sixth week.

1. Fertilization, and development of the embryo of a flowering plant.
2. General review and summary of the life history of a vascular plant.

III. SURVEY OF THE PLANT KINGDOM.

3. Myxophyceae. *Gloeocapsa*, *Oscillatoria*, *Rivularia*.
4. Chlorophyceae. *Chlorococcum*, *Ulothrix*.
5. Chlorophyceae. *Oedogonium*, *Spirogyra*.

Seventh week.

1. Desmids and diatoms.
2. Red seaweeds. *Nemalion* and *Polysiphonia*.
3. Brown seaweeds. *Ectocarpus* and *Laminaria*.
4. Brown seaweeds. *Fucus*.
5. Bacteria. Their relation to decomposition, fermentation and disease.

Eighth week.

1. Mucor. A discussion of saprophytism.
2. *Albugo* and *Peronospora*.
3. General discussion of plant diseases with examination of illustrative material.
4. *Plowrightia*.
5. Smuts of corn and wheat and their economic importance.

Ninth week.

1. Wheat rust. Study of the life cycle with observations of the effect on wheat.
2. Gymnosporangium. Its life cycle and economic importance.
3. Mushrooms.
4. Puffballs.
5. General review of fungi and plant diseases.

Tenth week.

1. The moss gametophyte and sporophyte.
2. A liverwort.
3. The fern. A review of its life cycle and its position in the plant kingdom.
4. Lily and Iris.
5. Grass and sedge.

Eleventh week.

1. Buttercup and pink.
2. Crucifer and mallow.
3. Morning glory and mint.
4. Apple, cherry and pea.
5. Parsley and composite.

Twelfth week.

1. Identification and habitat of prairie plants. Field work.
2. Identification and habitat of prairie plants. Field work.
3. Identification and habitat of wood plants. Field work.
4. Identification and habitat of wood plants. Field work.
5. Identification of trees. Field work.

"An elementary course to be effective must do three things: *First*, it must give the student an idea of the vital activities of plants to such an extent that they can make practical use of the knowledge in agricultural work and in everyday life: *Second*, it must lay before the student the possibilities of advanced study. *Third*, it must lay a foundation upon which advanced study can be based. For these reasons the course must contain some of each of the following: physiology, ecology, pathology (the more practical lines of study) together with enough taxonomy, phylogeny and histology to make the other lines intelligible."

(To be Continued.)

ARIZONA.

BY JEHIEL S. DAVIS,

Prescott, Arizona.

To the minds of many, even in the mountain states, the name Arizona brings many false impressions. It is often regarded as a section of heat and desert waste, a strange borderland in a blazing sun, a mañana country sleeping between the east and west.

The meaning of the name of the state is in doubt, being given by different authorities as "Little Creeks," "Blessed Sun," and "God Enriches." The state flower is the white waxy blossom of the Saguaro, or giant cactus. This cactus is very characteristic of the state and sometimes grows to a height of forty or even fifty feet.¹ The state flag is the flag of the copper star.²

Arizona is a great irregular rectangle in the southwest, lying partly in the lowlands along the Colorado River and towards the Gulf of California, and partly on the bleak Colorado Plateau. Its latitude is about the same as that of Tennessee and Georgia, Morocco, or Tibet. The northeast corner of the state touches Colorado at the only place where four states meet in one point, and from southern Utah and Nevada it extends south to Mexico entirely between the two great ranges of the cordillera, the Coast Range in California and the Sangre de Cristo and Sacramento Ranges in New Mexico. Arizona touches only the Mexican state of Sonora to the south, where there has been little border trouble. This is because most of the international line is in the almost uninhabited Sonora Desert, and much of this is but a narrow strip of land sixty or seventy miles wide between the United States and the Gulf of California.

The westernmost important towns in Mexico are south of the eastern third of Arizona. The state has an area of 113,810 square miles practically all draining into the Colorado River. A few desert valleys in the south such as the Rio Sonoyta and Rio Asuncion or Altar River go directly to the Gulf of California. Roughly the southern quarter of Arizona or a little less, makes up the bulk of the Gadsden Purchase acquired from Mexico in 1852, four years later than the rest of the territory. Arizona was made a territory in 1863, when the trading post of Navajo was the capitol. The capitol was later removed to Prescott, then to Phoenix. Arizona became a state in 1910.

¹Nat'l. Geog. Mag. Vol. 31, 1917, p. 513.

²Nat'l. Geog. Mag. Vol. 32, p. 334.

Arizona is mountainous over most of its extent and there are probably no sections in the world more marvelously rough than parts of the state.³ Some sections are flat however, and there are large divisions differing widely in type. The state may be divided in three great sections, on the basis of climate as well as surface.

The great rectangle of the state is belted diagonally across with rugged mountains from the northwest, towards Nevada to the southeast where the El Paso and Southwestern Railroad winds through the San Bernardino Valley to Douglas in the country described by Zane Gray in *The Light of Western Stars*. Northwest of the mountain belt, the Colorado Plateau rises away into Utah, Colorado, and New Mexico averaging from 4,000 to 8,000 feet in elevation. On it are scattered mountain ranges, many of which are volcanic in origin as are the graceful cones of the San Francisco Peaks which rise to 12,611 feet elevation, the highest point in the state. Some of these evidences of volcanic action are old and worn by ages of weather but others look as though they had been active yesterday. However, the most marked characteristic of the surface of the plateau is the canyon formation which dissects the comparatively flat surface in all directions. This formation culminates in the master gorge, the Grand Canyon.

The great diagonal mountain belt to the southwest of the plateau ranges in elevation from 2,000 to 12,000 feet and really marks the breaking down of the plateau. Peaks rise above the plateau land, but much of the surface, although mountainous, is lower than the flatter surface of the plateau. Some of the rivers flow from the plateau clear through the mountain belt and where the latter forms important divides these run along the edge of the plateau.

South of the mountain belt and to the west, along the Colorado River, are the broad desert lowlands cut by fantastic shaped mountain ranges in a way somewhat opposite to that in which the plateau is canyon cut.

Flagstaff is typical of the cold northeast plateau division. It stands at an elevation of 6,907 feet. Because of the elevation and the fact that there are broad openings of lower elevation all the way to the Pacific Ocean the climate is rather cold and moist, quite different from what many picture for Arizona. The average annual rainfall is 23.87 inches or enough to grow

³Nat'l. Geog. Mag. Vol. 32, p. 490.

most crops without irrigation if it were not too cold. The average annual snowfall is 83 inches and the relative humidity 62%. The highest and lowest temperatures observed are 93° above and 21° below zero. The average date of the last killing frost is June 7, and that of the first September 20. The climate is sufficiently cold, so that snowshoes are not a curiosity and moving picture companies find excellent Alaskan scenery.

Globe, elevation 3,525, and Prescott, elevation 5,346 feet, are both in the mountain belt. At Globe the average annual rainfall is 16.22 inches while it is 17.4 inches at Prescott. Both of these are higher than the rainfall at San Diego, California, directly on the coast. The snowfall averages 7 and 30 inches respectively. The average relative humidities are about 45% and 55% and the lower the elevation the more continuous the sunshine. The highest and lowest temperatures are 110° and 11° above zero at Globe and 104° above and 12° below zero at Prescott. The average latest and earliest frosts are March 23 and November 17 at Globe and May 21 and September 29 at Prescott.

Typical of the lower desert sections are Phoenix, elevation 1,108 feet, the capitol and largest city of Arizona, and Yuma, elevation 141 feet only, 90 miles from the Gulf of California on the Colorado River. Phoenix has an average annual rainfall of 7.39 inches and Yuma 3.26 inches. There is no snowfall in either place. The humidities average 40.5% at Phoenix and 46% at Yuma. Because Yuma is so near the ocean, its average humidity is an exception to the rule that the lower the elevation the lower the humidity, but there are times when the movement of the air is towards the water that the humidity becomes remarkably low, sometimes below 5%. An impression has grown up since the opening of the irrigation project around Phoenix and Yuma, especially the former, that the humidity has been much increased by the cultivation, but this is shown to be untrue as the measurements of the weather bureau fail to show any appreciable difference in the average. The reason is of course, that the irrigated patches of 200,000 acres or less, are but dots of green in the hundreds of thousands of square miles of desert extending far into Mexico.

The highest and lowest temperatures are 117° and 16° above at Phoenix and 120° and 22° at Yuma. Many are afraid of the summer temperatures in this section, but this fear is groundless. The temperature at the surface of the body is determined largely

by the rate of evaporation of the perspiration and in this dry section this is very high, so that the sensible temperatures are very much like those in the central part of the United States or less. This is proven by the fact that heat prostrations common in the sections east of the Rockies are almost unknown in the southwest. To most people who come to southern Arizona during the cool parts of the year and remain through the hot weather this is no more uncomfortable than summer weather in the east and it is a great asset to the farmers. The clear weather with continued sunshine is delightful, and it is at Yuma where the sign over the depot restaurant reads, "Free meals every day the sun does not shine." The average latest and earliest killing frost dates in Phoenix are December 6 and February 16, but around the city there are sections where the air drainage prevents most of the frosts, and citrus fruit culture prospers. There is no record of a killing frost at Yuma.

The leading industry in Arizona is mining, and the state leads all others with a rank as follows in 1916: Arizona \$203,000,000, Montana \$145,000,000, and Utah \$97,000,000. The most important product is copper, which comes from various parts. The largest producers are in the mountain belt as the Globe-Miami, Bisbee-Douglas, Clifton-Morenci, and Jerome-Clarkdale sections. Gold, silver, and lead are important and the total of all the mineral products would make a long list. There are beyond doubt very rich coal and iron deposits in the northern part of the state. These are not yet mined, being in sections not yet carefully explored either because of the large Indian Reservations or the isolating effect of the Grand Canyon. The Indian Reservations were largely opened to prospecting within the last few months.

In the cold plateau there is much pine forest, largely under the United States Forest Service, and lumbering and grazing are the chief industries. Through the great expanses of unsettled mountains and canyons roam many wild animals among which are deer, lion, coyote, bear, fox, small rodents and others.⁴ The open expanses of the plateau are well described by Zane Gray in *Riders of the Purple Sage* and *The Rainbow Trail*. There are a few agricultural communities based on dry farming and irrigation, in the lower parts, especially along the Little Colorado River. All these things are sufficient to support only a scattered population, and a few small towns the largest of which is Flag-

⁴Nat'l. Geog. Mag. Vol. 30, pp. 409, 411, 413, 419, 423, 440, 442, 447, 450-1, 454, 458, 463 and Vol. 33, pp. 404, 405, 429, 438, 437, 440, 441, 456, 465.

staff, with about 3,000 people. Flagstaff is located in the Coconino National Forest and is a pine lumbering and stock raising center. Because of the cool summer climate and remarkable scenery it is an important summer resort. At Flagstaff are located the Lowell Observatory famous for studies of the planet Mars, and the Northern Arizona Normal School. There are large lime kilns at Nelson. Seligman is a small but rather important cattle center, Winslow is a farming and cattle town having also the railroad division point, and Holbrook and St. Johns are farming and cattle towns.

Farming is also of little development in the mountain belt, although in a few places as in the Gila Valley, irrigation supports good sized communities with such centers as Solomonville, San Carlos, and Thatcher. In the Globe district where flat land is very scarce, there has been hardly a start made, and farther northwest near Prescott where the elevation makes it colder, but a very small part of the land is farmed. However, rapid development is under way in the lower valleys and results are wonderful. Many of the products, especially peaches, apples, and alfalfa are not excelled anywhere, in quality. The pine forests cover the higher parts of the mountain belt even as far south as the Mexican border, but there is very little lumbering. Stock raising is important and is pictured by Harold Bell Wright in *When a Man's a Man*. The great copper centers of the mountains have been mentioned. Most of these are located much as is Globe, in a rugged canyon like valley, and possess a romantic beauty and interest in spite of a certain crudity and the still lingering air of misery and woe, held perhaps, by the plate glass fronts of saloons, gambling houses, and dingy rows of redlight cells which still remain to testify of the wild wide open days of not so many years ago. Prescott is the same, although not as large as Globe, and at some distance from the mining developments for which it is the distributing center. Prescott is a county seat and the largest town in the northern two-thirds of the state. The chief industry of the town is the Santa Fe Railroad shop. It is also a grazing center. Kingman is a combined stock and mining center. Asbestos is mined in the White Mountains near Roosevelt Dam. A number of the copper centers are larger than any other towns in the mountain or plateau sections. Bisbee is a city of 25,000 and Lowell, Douglas, Globe, Miami, Clifton, and Morenci, range from 4,000 to 10,000 although exact figures cannot be given until returns from this 1920 census come in.

Mining is also important in the desert, and the type of production is like that already mentioned. There are many centers such as Nogales, Ajo, Polaris, Wickenburg, Swansea, and Hraqua Hala, none of which compare with the mining centers of the mountain belt. The important thing in this land of summer, desert, and beautiful fantastic mountains, is irrigation farming, and this is what supports the largest centers in the state.

The Salt River Valley is the largest farming section, and Phoenix in the midst of it, the capitol and largest city of Arizona, has 32,000 people. It is pronounced by many, the fairest city in the intermountain region, from the standpoint of climate, beauty, comforts, and surroundings. It is chiefly a distributing center and the leading industry is the garage and machine shop based on the farm machinery, tractor, and automobile industries in many small units. Dairying, cotton ginning, and flour milling are other important industries. The most of the irrigation is under one of the largest United States Reclamation Projects.⁵ It cost over \$10,000,000, and irrigates 189,000 acres of land, raising almost anything that grows and cotton, alfalfa and dairy products in largest quantities. It is expected that the acreage will be increased to 219,000.

The water storage is accomplished by Roosevelt Dam about eighty miles eastward, and north from Phoenix on the road to Globe. This great dam, half again higher than Niagara Falls, stores the flood waters from a great area in the mountain belt and regulates their flow so that they will be available for irrigating the desert below. The project supports several other large towns. Tempe and Mesa each have about 10,000 people. Tempe is the seat of the Southern Arizona Normal School and has one of the condenseries of the Pacific Creamery Co. (Armour & Co.) as well as a cotton gin. The other Pacific Creamery is at Glendale. Mesa is an important Mormon town. All around the project, private pump irrigation development is going on. A project to dam the Hassayampa River and irrigate a large tract of land near Hot Springs Junction is reported under way.

The second city in Arizona is Tucson, where is located the State University. The population of Tucson is about 25,000 and the city is surrounded by irrigated farms of the finest quality. The elevation is about 2,000 feet, making the climate very good. Many small projects are springing up where water has been found, and while this will always be a region where there is

⁵Journal of Geog. Vol. 11, May, 1913, pp. 277-284.

elbow room, it will be dotted by many large garden spots of green, many more than now appear.

Yuma is surrounded by another United States Reclamation Project. The water is taken from the Colorado River at the Laguna Dam. Yuma has the advantage of more continuous sunshine and heat, and of being almost free of frost. This has made possible such production as 7.5 tons of alfalfa on 7.1 acres. Yuma is one of the gateways to Arizona. There are but three places where the Colorado River is bridged, Yuma, Parker, and Topock near Needles, California. Here the two Santa Fe Lines and the Southern Pacific cross, connecting Arizona with the coast and paralleled by automobile roads, two of which are transcontinental highways. Transportation is so difficult in Arizona, that its development has been much retarded and it in turn has held up other kinds of development. The canyons in the plateau, offer great engineering difficulties, and many parts of the mountains are so rough that it is hard to put a road or railroad through at any cost, while on the desert there is not enough water easily obtainable to operate the railroads in many places, causing great expense to run through empty country. Great distances and thin population also make it impossible to improve the automobile roads as they should be. There are many types of road in Arizona, but the most marked types correspond to the divisions of the state, desert, mountain and plateau. The desert roads are sometimes good, as the grade is near level and the usual adobe soil makes a hard road until wet, when it becomes terrible, and often dries rough and remains so for days. Many of the plateau roads are on volcanic or other clay, and are good when dry and hard but are much more often mired and they run over grades that make these difficulties much greater than on the level roads. In the mountains there are many places where grade and surface make roads practically impossible, except at great expense and with fine engineering skill, so the main roads in many of these places have been built most excellently, and are fine smooth roads. Some have been allowed to wash on the surface until the uncovered rough bare rocks make them nearly impassable. It will be seen that most of the difficulty with roads can be overcome by paving over flat country or grades already built; it is to be hoped that the state extend the few miles of pavement near the larger towns and connect them up. In spite of the size of the state, 1,800 miles of pavement could be made to reach every town of 1,000 population or more, and

many points of interest, as well as covering the Arizona parts of the National Old Trail's Road, along the Santa Fe, the Apache Trail and the Borderland Trail in the south. Once paved, these roads would be open to easy travel the year round, as even in the highest sections of the National Old Trails road the snow would seldom be found deep enough to stop traffic over a paved road.

To the sight-seer, the railroads are of little value except to get into the state. Almost everything of interest is off the main line of the railroad, off the main road, or off any road, yet it would be hard to find a section of equal size with so many things of great interest crowded into it. Arizona has two National Parks, Grand Canyon, made a park in 1918,⁶ and Casa Grande Ruin. Grand Canyon cannot be described. World travelers pronounce its beauty as well as its grandeur, unequalled, and I know by experience that it is so large that one cannot see it from the rim, but must go down the trail into that colored wonderland to even get a suggestion. The canyon is 250 miles long, one mile deep, and averages eight miles wide. Scattered cliff ruins add a romantic human touch to the exploration of these ever changing unpictured tinted crags.

Casa Grande Ruin, made a park in 1889, is the ancient ruin of a community house or town on the desert near Florence. It is thought to be the remains of a people even more ancient than the cliff dwellers who preceded the Indian.

Just beyond the limits of Arizona to the northeast in Colorado is Mesa Verde National Park containing in its 77 square miles of area the most notable, best preserved collection of cliff ruins in this country and also a great many pueblos.⁷

Arizona has seven National Monuments, of which the Petrified Forest is probably the most interesting. As it is the best known collection of agatized trees and should be a park. It is near Holbrook on the National Old Trails Road. Walnut Canyon, Montezuma, and Tonto are all monuments to preserve cliff ruins. The first is near Flagstaff, the second between there and Prescott and the last near Roosevelt Dam. Pueblos and works of the Indians are found in the Navajo National Monument far in the north, while just across the line from it into Utah, is found Rainbow National Monument, containing the largest known natural bridge, 308 feet high, called Nonnezoshe, by the Indians.⁸ Just

⁶Bul. of the Pan-American Union, Vol. 13, Oct. 1916.

⁷Bul. of the Pan-American Union, Vol. 44, April, 1917.

⁸Nat'l. Geog. Mag., Vol. 29, p. 376.

north of Tempe, red rocks rise from the plain, creating a spot of wild beauty in the very midst of the irrigation project. Here is Hole-in-the-rock, a small natural bridge, where the Apaches used to ambush prospectors. Over this area grow fine specimens of the saguaro cactus. To the east is a Papago Indian reservation and the whole makes up the Papago-Saguaro National Monument. Far to the south is Tumacacori,⁹ set aside because it includes the ruins of a mission and relics of the work of monks with the Indians.

Outside the national reservations are many other wonders, as the Apache Trail from Globe to Phoenix,¹⁰ the Roosevelt Dam on this road,¹¹ Mission San Xavier del Bac¹² near Tucson, New Cave near Flagstaff, Cathedral Cave north of Prescott, Inscription Rocks near the Williams River, and other scattered inscriptions, Indian ruins, cliff dwellings, mountain scenery and the like.¹³

Empty as it may look from the train, Arizona has an overabundance of world wonders, and better still, mineral and agricultural wealth. Here is every type of climate but the damp tropical, and even now a moving picture company is in Prescott taking pictures of the Canadian Mounted Police in the far northwest, while by a half day automobile trip they could be filming the Sahara, the orange groves, Alaskan snow games, or the Hopi Snake Dance.¹⁴

⁹Sunset Mag., Vol. 43, p. 24, Nov. 1919.

¹⁰Nat'l. Geog. Mag., Vol. 32, p. 490, Fish Creek Hill.

¹¹Journal of Geog., Vol. 11, 1913, p. 281.

¹²Arizona Mag., Vol. 10, 1919. (Aug.) Sunset Mag. Vol. 43, p. 22, Nov. 1919.

¹³Nat'l. Geog. Mag., Vol. 29, p. 375.

¹⁴Nat'l. Geog. Mag., Vol. 29, pp. 385, 392, 397, 398.

OFFICIAL TELLS ADVERTISING MEN NEED OF METRIC UNITS—METER-LITER-GRAM.

In a recent address before members of the Advertising Club of Baltimore, Md., H. D. Hubbard of Washington, D. C., Secretary to the U. S. Government Bureau of Standards made an earnest plea for the adoption of metric units of measurement in the United States.

Mr. Hubbard pointed out that, during the war, American manufacturers were forced to use the metric system in the manufacture of guns and other ordnance, and two principal American locomotive works had to use it in the building of locomotives. If the work on the blue prints for these locomotives had to be done in feet and inches, Mr. Hubbard said, the locomotives would never have been built. He further said that America by refusing to adopt the metric units is keeping herself as far behind in the matter of proper standards as was China, who has now adopted metric units.

STANDARDIZED TESTS IN SCIENCE.

BY RALPH E. WAGER,
Normal School, De Kalb, Ill.

(Continued from December, 1919.)

Passing now to the third point, that of method, let me state at the outset that I have no idea of attacking the general plan of current procedure of making use of both laboratory and textbook. A passing allusion to the too great attachment to the textbook on the part of many teachers, together with the neglect of the laboratory phase of the work, is sufficient to call up one of the most serious errors. It is not merely information we should strive to put over, but rather an attitude of mind, or a way of thinking, recognizing meanwhile of course, that some knowledges are worth while in many ways. But the too constant and insistent effort merely to obtain a recitation in terms of the textbook develops only an attention to the matter of memorizing enough to satisfy the requirements of the teacher whether or not a significance obtains.

I have already alluded to the project as a scheme for making use of the larger life-environment of the child as the laboratory. This offers boundless possibilities. It seems then that we should develop projects in conformity with this idea and try them out. Probably a helpful undertaking would be to list all such and submit them to earnest teachers for trial and criticism. Inasmuch as reference has been made to the desirability of standardizing such projects we may leave this point without further discussion. To pass then to another related phase, I would like to call attention to the fact that there is need for experimental teaching, and considerable investigation into the most economical and efficient methods of procedure; such as, for example, that of Gilbert, in which he compared the results in teaching zoology when emphasis was placed on the economic approach and that of pure science. Or such as Webb's study in the comparative results in teaching chemistry by laboratory, lecture and combination methods. We need thorough surveys of the content and capacities of pupils at the time they enter our classes. Grier's report on the results of his range of information test in physiology is most suggestive in that he discovered that much of the current terminology, and presumably, therefore, no little of the meanings, of hygiene, is obtained outside the classes dealing with that subject. Newspapers and magazines have

done much to educate the layman. We should know where to begin without loss of time and effort.

All of this type of investigation demands, however, the formulation of standardized tests. Before we can do that we must have a certain starting point in both content and purpose. With such instruments results by different methods become measurable and comparable. Without them they remain as now, mere matters of opinion.

Still another point remains to be made in this general connection. The realization of the great differences in the capacities of pupils is leading to well developed means of making a division of our school population into at least three large classes: the dull, the medial, and the bright pupils. I am assuming that no genuine subnormals find their way into the high school! In English and history as well as mathematics, this division is finding favor. It remains for us then, to develop means for separating pupils into similar groups according to their capacities to do the work in science. Thereafter it is essential that the work be made to fit the group. Herein is, I think, one of the most important and essential steps we can take, and its importance cannot be overemphasized. As scientists we should not bring up the rear when the application of scientific methods is involved.

Mention has been made of the standard test as an important and essential tool. Undoubtedly many of you are familiar with the beginnings already made to develop it, although none with which I am familiar have been well standardized. Some of these are: Grier's Range of Information Test in Zoology and Physiology, Downing's Range of Information Test in Science, Bell's First Year Chemistry Test, Caldwell's Garey Survey Tests, Herring's Test of Abilities in Scientific Thinking. As I have stated, these tests have not been standardized. For such a process, a group of schools cooperating, let us say for two years, ought to yield a test of sufficient reliability to make it worth while.

We come now to a point from which I wish to digress a bit from the general implications of my topic, but I feel that your interest in the undertaking I have in mind to suggest will carry us along in a spirit of cooperation.

If you will put your ear close to the ground, you will hear rumblings of dissatisfaction with our present content in history. Already ancient history has been relegated as a requirement by some of the leading universities, and thoughtful laymen are

asking as to why so great emphasis is being placed in our present history courses upon the political and military aspects. Labor unions are demanding that history be taught from the viewpoint of the development of industry. There has been appointed, I understand, a committee of noted historians to make certain revisions in the history outline. Now, why not, let us ask, teach the origin and growth of the great ideas in science as a part of, yes, indeed, as the basis for, an understanding of industrial developments? Quite generally the mission of science and scientists is entirely misunderstood; and for good reason. Did people generally know something of the nature and significance of the contributions science has made to the happiness and welfare of man, and of the infinite patience and unflagging labors involved in their discovery, much good would come through a more wholesome respect for them. Yet ignorance is all too patent with reference to both the principles and the men who discovered and formulated them. As an illustration let me present the following bit of evidence: A few days ago I tried out a class to determine if some of the common names in science were familiar or unfamiliar, and if the former, to what nationality its possessor belonged. This test is about as simple as one could be made. There were thirty-one pupils, all high school graduates. The results:

Name of Scientist	Heard of or read the name	Nationality		Nationality known	Nationality unknown
		Unfamiliar	known		
Tyndal	9	22	4	27	
Pasteur	13	18	4	27	
Lyster	0	31	0	31	
Koch	2	29	0	31	
Huxley	15	16	6	25	
Darwin	30	1	19	12	
Lamarck	0	31	0	31	
Priestley	3	28	0	31	
Copernicus	3	28	0	31	
Galileo	16	15	0	31	
Bessemer	1	30	0	31	

Choosing the name most familiar I then asked for some definite association with it. The results are most suggestive. With the name of Darwin these associations were reported:

No. of Pupils

- 20—The originator of the theory of evolution.
- 1—Something to do with religion.
- 2—A great atheist.
- 1—A botanist of great renown.
- 1—A great scientist.
- 1—A scientist and atheist.
- 1—The originator of the idea of sexual selection.
- 4—The originator of the ideas concerning the origin of species.

It seems hardly possible that these young people have come up through our high schools with these notions, and yet it is not surprising when you contemplate the manner in which history has been presented. Would it not lend somewhat, I would like to ask, to the feeling of brotherhood between nations, and to realization of the mission of science, were pupils in our schools to discover that to science all civilized nations have made contributions, and that to all nations it has ministered in so far as they have been able to adopt and make use of it? I would then, suggest a course in the fourth year of the high school, or before if possible, dealing with the development of science in the world, and with some of the large ideas which have contributed so bountifully to the cause of civilization. Such a course would serve to tie the science together into a unified whole, furnish at the same time an opportunity for a review of the salient points in each science element, and at the same time present a true picture of man's progress toward his present control over Nature. By whom such a course were taught were immaterial in so long as he permits the pupil to discover the truth and think for himself. If we are about to enter upon an age dominated more and more by scientific thought and method, certainly the high school should strive to give at the least an understanding of the history and mission of science. The *odium religicum* is so far decadent, let us hope, as to make such a course possible. There is opportunity also for brief and simple biographical sketches of the lives of scientists for use in the upper grades.

I come thus, by a somewhat circuitous route, to the statement of a plan for the development of standardized tests. You will suspect me of trickery for I have managed to bring into my discussion some apparently unrelated materials. When, however, you think the problem through, you will understand that before useful tests can be made all these other facts must be passed in review, evaluated, and procedure directed accordingly.

A summary of the points I have tried to make may now be made. They involve:

I. A survey of the outcomes of the present courses of study as they are presented in a series of typical schools. We must satisfy ourselves as to what we are now accomplishing.

II. The establishment of definite aims after (a) reviewing the present outcomes, (b) examining the courses in the curriculum to which our subjects may contribute, (c) attempting to discover vital relations with actual life activities.

III. The development of standardized tests based upon the aims thus set up.

IV. The initiation of experimental teaching (a) to determine the most efficient methods, (b) to discover the most difficult and most commonly misapprehended points in the subject matter from the pupils reaction to them.

V. To list, standardize and develop projects and problems.

VI. To devise means for grouping pupils according to abilities in science work, and to adapt materials to such abilities.

Somewhat apart from this logical sequence in the larger plan is that concerning the introduction of the history of the great scientific ideas and their relation to man's progress. This involves investigation and agitation as well as the organization of such a course as to content.

Finally, if we are to bring our science work into accord with modern educational demands, and if we are to keep pace with the progress now being made in other subjects, we must follow some such plan as I have tried to present. I therefore submit it for your consideration and frank criticism.

TEACHING BOOKKEEPING BY THE HISTORICAL METHOD.¹

By A. P. R. DRUCKER.

Those who have had experience in teaching bookkeeping know only too well the difficulties they have encountered in their attempt to explain to students the reasons for the rules of bookkeeping. Indeed, very few teachers ever try to assign reasons for these rules; they simply insist that the students master the rules and then work out the exercises illustrating their application. In other words, they teach the hows but not the whys of bookkeeping science. The result of this insistence upon the memorizing of unexplained and uncomprehended rules is naturally more or less confusing in the minds of the learners. The vagueness of the subject finally discourages the students, who are for the most part groping in the dark, never sure of their ground, their weak grasp of the subject becoming fatal to their enthusiasm.

The answer of a certain student to the question—what would he do in case he received a telegram from the freight agent notifying him that the consignment of goods he had expressed to John Brown had been destroyed en route: that he would debit the telegram in accordance with the rule to "Debit whatever is received"—ludicrous as it may sound, is nevertheless typical of the bewilderment resulting from the usual vague presentation of the subject and of the uncertainty the student feels in trying

¹Address made before the Commercial Section of the Oregon Teachers Association.

to apply the rules of bookkeeping to business transactions. As a matter of fact, very few even among practical bookkeepers have more than a hazy idea about the application of the rules of the subject.

By defining bookkeeping as an art, the old textbooks themselves admitted that the rules of the subject are those of an art—intuitive only, and therefore not referable to reason or demonstration. In this way they evaded the necessity of assigning reasons for the rules of debit and credit.

This method of teaching bookkeeping, however, is not only futile, but it is also far from a true appreciation of the rules of the subject. For these rules are no more inexplicable or obscure than are the rules of arithmetic or algebra. Bookkeeping rules, like those of mathematics, are based on logic pure and simple. For indeed the obscurities ordinarily attributed to them are more apparent than real, more due to a lack of historical perspective than to the fact that the underlying reasons cannot really be found.

The obscurity surrounding the rules of bookkeeping is largely due to the peculiarly uneven historical development of the subject during the centuries of its growth. If we study the history of bookkeeping carefully, we shall find that while the systems, forms, and methods of bookkeeping progressed steadily, in accordance with the demands of business needs, the rules were not changed to fit the new conditions. Instead, they were simply extended—stretched out, as it were—to embrace the newest methods and devices. Under these circumstances it was only natural that the rules when taken out of their historical setting and applied to new systems and practices, should lose their original axiomatic reason and appear obscure and incomprehensible. By looking at these rules from a historical standpoint, however, we can readily detect not only the basic reasons but also the logical and reasonable method of development.

An illustration will make this point clear. If a student should ask the instructor the reason for the rule to "Debit cash when it is received into the business," the instructor would be at a loss for a clear explanation. If he himself has never studied the subject from the historical standpoint he will be quite unable to assign any reason for this rule. Some authorities, in their endeavor to give some kind of explanation for the rules of debit and credit, have resorted to rather fanciful reasons. They have adopted what is known as the "personification idea"; that is, they have

personified the impersonal accounts. We debit personal accounts, they say, when the persons receive something of value from the business. In the same way we may personify cash and thus debit it when "cash" receives money, because we look upon cash in the light of a person. Such a fantastic and rather farfetched explanation goes to show the straits to which the teacher is driven in trying to find some kind of reason for an apparently obscure rule.

Again, Professor W. M. Cole of Harvard has modified this personification idea somewhat by a rather ingenious turn. He tells us that *debit* means assuming responsibility, and *credit* releasing responsibility. In personal accounts, Professor Cole reasons, we debit a person who buys goods of us because he becomes responsible to the business for the debit, and we credit him when he pays the debt because by paying he is released from his responsibility. By applying the same idea to impersonal accounts, Professor Cole assumes that when cash is received into the business, *cash* becomes responsible for the amount thus received and hence is debited for the amount. On the other hand when money is paid out of the business cash is credited for this amount because "cash" is released from its responsibility for the amount in question.

While this explanation is most ingenious and in many instances most helpful, it is nothing more than a fine modification of the old personification idea. We hold "cash," an impersonal object, responsible for money it receives by personifying cash. Besides this attempted explanation does not account for all the applications of the rules of debit and credit. It cannot for instance explain these rules as applied to profit and loss. Why should we credit profit? Where is the responsibility released?

But above all, neither the personification idea nor its modification, the "responsibility idea," are true to the historical development of bookkeeping. Neither of these ideas were in the mind of the bookkeeper who first extended the rules of debit and credit, to impersonal accounts. In order to arrive at a true insight into the mental attitude of the originator of the application of the old rules for debit and credit to cash in double entry bookkeeping, let us for a moment trace the historical development of bookkeeping and note the actual reasons for the application of the rules of debit and credit to impersonal accounts, as they occurred to the inventor of the system.

The first attempt at scientific bookkeeping was the single-

entry method. At first only the daybook was used. In this book only personal accounts were recorded, and in this connection of course the terms *debit* and *credit* had a clear meaning. The word debit comes from the Latin verb "debere," to owe; credit is derived from the Latin verb "credere," to trust. Hence, these terms when applied to personal accounts had a perfectly lucid meaning. The term debit, meaning "he owes," was applied to a person who purchased goods of the business on account; while the word credit, which means "he trusts," was applied to a person who sold goods to our firm on account and trusted us for the amount. Therefore, the rules for debit and credit were as follows:

"Debit a person for what he receives from the business on account (i. e., for what he owes); and

"Credit a person for what he gives to the business on account (i. e., for what he trusts)."

At this stage of its development, bookkeeping called for such books of record as helps to the memory only; hence, where there was no need to remember an item of business, there was also no need to keep a record of the transaction involved. Accordingly, when a customer paid his debt to us or when we paid our creditor, the transaction was completed and the account was crossed off the books. Hence, there was no other record made of the payment.

The growth of commerce, however, made this simple kind of bookkeeping impracticable. Customers sometimes paid only a part of their debt and thus placed the bookkeeper in a dilemma as to how to keep a clear record of their account. Or again, we bought merchandise of a certain firm several times in the course of a short period. Under these conditions it became easy to make mistakes, such as crossing off the wrong transaction. Besides, it took a long time for the bookkeeper to locate the various items relating to the one customer in the many pages of the "day-book" in order to know whether this customer bought four or five times in the course of a month. For these reasons the helpful ledger with its assembled accounts under the names of the various persons doing business, made its appearance.

The ledger carried with it a new and revolutionary principle, namely, the principle of "counterbalancing" accounts. The whole principle of the ledger is derived from the action of a pair of scales or perhaps a lever and a fulcrum. When the bookkeeper observed how one scale with a weight could be counterbalanced

by placing an equal weight on the other scale, he thought that the same principle could be applied to his ledger. If one side of the account is weighted down because of merchandise sold, then when payment is made, this cash amount when placed on the other side of the ledger should counterbalance the original account. Therefore, not only did the bookkeeper of this period adopt the system of vertical and horizontal crossbars in his ledger—a device resembling the ancient form of a pair of scales, but he also adopted the principle of a pair of scales in his book-keeping by virtue of which, instead of subtracting one amount from the other when payment was made, he simply placed the subtrahend on the side opposite that containing the original item, and thus he counterbalanced the original account and made the two sides balance.

Under the ledger system, therefore, when an account was paid, instead of cancelling the old items or subtracting the money payment from the value of the merchandise item as was the old method and is still done in the arithmetical process, the book-keeper placed the payment of the cash on the side of the ledger opposite that showing the original indebtedness, and the account was thus equalized or counterbalanced. The original rules of debit and credit were not changed, however; instead, their meaning was extended to include the new method. Thus the rules still read the same as before; "Debit a person for what he received from the business; and credit a person for what he gave to the business." Now, however, the meaning of the word *debit* was not limited to the case of the person buying the goods of us on account and thus really owing us money; but it was applied also to a person who received money of us for a debt we originally owed him. We now "debit" this person even though he does not owe us anything. This debit is nothing more than a counterbalancing or rather offsetting of the item on the other side of the account, the original item. And since the former happened to be a credit, we call its offsetting or counterbalancing item, a debit. The same idea holds true of the term *credit*. This term also is not limited now to the person who gives or entrusts merchandise to us on account, but it is also applied to the person who has paid us an old debt for which we had originally debited him. Being thus credited does not mean that this person trusts us for anything; it is used merely as an offset or counterbalance to the original debit item, and is therefore called a credit notwithstanding the original meaning of the term *credit* does not apply here.

This extension of the original meanings of the terms debit and credit was legitimate, because it followed in every instance the rule originally laid down for debiting and crediting. We debited personal account when the person received something (this time cash) from the business. Likewise we credited the personal account when the person gave something (in this instance cash) to the business.

It was the idea of balancing and counterbalancing accounts in the ledger that suggested the principles of Double Entry to the bookkeeper. It was apparent to every bookkeeper that a business transaction has a counterbalancing effect on the business; that is, the two factors that enter into the transaction counterbalance each other. In every transaction there are two factors, usually one personal and the other impersonal. If our business buys merchandise from John Smith on account, the two factors, Smith and merchandise, influence our business in such a way that their forces counterbalance each other—and so our business is left in the same condition as it was before the transaction. Suppose our business bought goods for \$1,000 on account from John Smith. In accordance with the rules of single entry, we would credit Smith for \$1,000 on our books. As the item is posted in the ledger it would show a liability on our business; it would show that we owe John Smith \$1,000; hence, our business apparently is poorer by this amount. But is the business really poorer? By no means, for as an offset to this recorded liability to Smith, the business has received an impersonal item, merchandise, worth \$1,000, as an added asset. Hence the personal liability incurred by the business in buying of Mr. Smith on account was offset by the addition of impersonal goods to the business.

The same principle holds true when the business sold goods on account. The personal account receivable that has apparently increased the assets of the business is offset by the amount of the goods sold to that person which is taken out of the business. Hence we see that in every business transaction one factor in the transaction offsets the other, so that the two counterbalance each other. Since accounts with these two factors would supplement each other, the idea suggested itself to the bookkeeper, why not keep a record with both, so that the books may always be in balance. The principle underlying this novel idea was not very complicated. All that was necessary was to apply this idea to the daybook and give it debit and credit columns and make

these two columns counterbalance each other. As the bookkeeper was already familiar with the idea of applying the terms debit and credit to offsetting accounts he could see no reason why the same terms could not be used in double-entry bookkeeping, by extending somewhat the ideas of these terms. For inasmuch as there exists a peculiar relationship in business transactions between the personal account and the impersonal item that was bought or sold, there was no reason why the words debit and credit could not be used including these ideas. In their original sense they could be used when they applied to personal accounts and in their expanded sense as counterbalancing or offsetting accounts when applied to impersonal accounts. Hence if we sold goods to Brown for \$1,000 on account, our bookkeeper would debit Brown for that amount—the word debit signifying that Brown owed us \$1,000. And as an offset to this personal debit to Brown, he would then credit an impersonal account—in this case merchandise, because it was for merchandise that Brown was debited. When Brown pays the \$1,000 we will credit his account, as explained before, as an offset to his original debit for the same amount. But in accordance with the rules of double-entry bookkeeping every credit must have an equal offsetting debit. Therefore, we debit an impersonal account—cash, as an offset or counterbalance, because Brown's personal account was credited for the cash he gave the business.

We can now understand the reason for the rule that cash is debited when received into the business. It is debited because the person who gave it was credited for it. Hence we debit the impersonal item cash that was given to the business in order to offset or counterbalance the personal credit.

From this historical illustration it will appear evident how the change in the methods of business forced the extension of the meaning of some of the terms beyond their original import, and consequently brought about an obscuring of the rules. The same holds true for some of the other so-called "obscure" rules of bookkeeping. The only way in which we can arrive at their underlying reason and explanation is by following their historical growth and noting their changed meaning.

In other words then, bookkeeping should be taught as a science and presented from the scientific standpoint, with reasons and explanations for its rules. In order to be able to explain the reasons underlying the rules, the teacher must follow the historical development of his subject from its early beginnings, showing

when, how and why the various improvements and modifications were made and the various rules applied. As the student learns not only the rules but also their reasons there is less and less need of routine memorizing and heavy lessons of practice work. As in the study of every other science, the students are thus given theory and practice in reasonable proportion. They themselves become interested and keenly responsive, and feel all along the way that they have the subject well in hand—a condition quite the reverse of the blind groping which has too long been the prevailing attitude of students of bookkeeping under the usual methods of teaching this subject.

THE RANGE OF INFORMATION TEST IN SCIENCE REVISED.

By DR. ELLIOT R. DOWNING,

The University of Chicago.

In a previous article (*School Science and Mathematics*, Vol. XIX, pp. 228-233) the present writer reported the returns from a range of information test given to several hundred High School Freshmen, College Freshmen and Sophomores. Since then the test has been given to several hundred additional pupils, including a large number in the Quincy, Illinois, Schools, principally in grades seven to ten. I am indebted to Mr. O. D. Frank for conducting the tests in the Quincy schools. The purpose of the present article is to present the results of these additional tests and to combine them with those before obtained. As was suggested in the preceding article, it seems advisable to cut down the test for High School pupils to fifty words instead of using the full one hundred, since many of the terms are quite unfamiliar to them. This will shorten the test, at the same time rendering it no less efficient. This article will present the revised test and the method of its revision.

The test given consists of one hundred words and phrases selected to suggest important generalizations in science that it might be reasonably anticipated would be meaningful as a result of Nature Study instruction in the grades or General Science in the High School. Roughly, one-third of these are taken from Biology, one-third from Physiography and Geography, and one-third from simple Physics and Chemistry. Each pupil is asked to mark with an "E" such terms on the list as he can define or explain, with an "F" those recognized as familiar but which he cannot now explain, and with an "N" those totally new. He is also asked to define or explain the first three he marks "E."

These definitions give a check on his own estimate of his knowledge. If one or more of his explanations are incorrect his "E" score is cut down accordingly, and his "F" score proportionately increased. Thus if a pupil marks twenty-one words "E," thirty "F," and forty-nine "N," and one of his three explanations is incorrect, his corrected score would be "E" fourteen, "F" thirty-seven, "N" forty-nine. Definitions or explanations are accepted as correct if they show the pupil has the right idea even if his explanation is not technically exact. The monotony of looking over these hundreds of papers is relieved by the humor of some of the definitions given. For instance "Adaptation" is often explained as "when you take somebody else's baby and treat it like your own." One ninth grade pupil defined "Photosynthesis" as "a disease from which one very seldom recovers. Generally when they recover it usually leaves them crippled in some way." "Battery pole" is defined as "where a ball player stands in the game to bat the ball." "Comet" is "where something funny gets done or acted."

The results thus far achieved are as follows:

TABLE I.

No. pupils tested.		Av. original score.	Av. cor. score.	Av. no. words scaled down.	% of scaling
238 Quincy, 7th grade	E	10.7	2.3	8.4	78.5
	F	19.	27.4	—	—
184 Quincy, 8th grade	E	13.3	4.6	8.7	65.5
	F	20.9	29.6	—	—
108 Uni. High, 9th grade	E	26.5	18.	8.5	32.1
	F	21.9	30.4	—	—
112 Fenger H. S., 9th grade	E	21.5	17.2*	4.3	20.
	F	17.1	21.4	—	—
226 Quincy H. S., 9th grade	E	25.2	17.3	7.9	31.4
	F	24.6	32.5	—	—
83 Quincy H. S., 10th grade	E	24.1	14.3	9.8	40.7
	F	28.9	38.7	—	—
141 DeKalb Normal School, Freshmen	E	34.6	34.6	—	—
	F	30.	30.	—	—
73 Normal School, Fresh., St. Louis & Kalamazoo	E	32.	32.	—	—
	F	33.9	33.9	—	—
83 DeKalb Normal School, Soph.	E	44.7	44.7	—	—
	F	32.7	32.7	—	—

It is rather remarkable that the three High Schools give results that are so nearly coincident. It is to be noted that the words marked "E" do not coincide as pointed out in the pre-

*An error in the preceding article gave the uncorrected figures instead of the corrected for the Fenger High School.

ceding paper. Yet even in this particular there is a much larger per cent of agreement than of difference. This will be seen from the following tabulation, and also from the accompanying graph which reveals the significance of the figures at a glance.

TABLE II.

Percentage of Pupils Marking Words E.
U. High. Fenger. Quincy. Av. 484 H. S.

				9th.
1. Action & reaction are equal	13.9	2.7	9.2	8.7
2. Adaptation	30.5	12.5	25.6	25.
3. Alpine flora	8.3	3.6	4.	4.8
4. Angle of reflection	17.6	4.5	4.8	7.6
5. Animal society	21.3	8.	15.4	14.9
6. Atom	47.2	52.6	62.8	53.7
7. Avagadro's law	0.0	0.0	.4	.4
8. Battery pole	10.1	8.	7.4	7.3
9. Buoyancy	50.	17.8	58.4	44.
10. Candle power	38.9	27.7	32.7	33.3
11. Center of gravity	40.7	19.6	14.6	22.5
12. Comet	48.1	41.9	46.4	45.
13. Commensalism	0.0	3.6	1.3	1.4
14. Composition of forces	11.1	2.7	7.9	7.2
15. Conduction	36.1	31.2	47.3	41.7
16. Conservation of energy	44.1	17.8	31.4	31.8
17. Dew point	82.4	67.8	81.8	77.3
18. Differentiation of tissues	7.4	3.6	4.4	4.9
19. Disease organisms	16.6	11.6	19.4	16.9
20. Drowned valley	26.8	40.1	8.8	22.1
21. Eclipse	71.3	60.7	67.7	67.2
22. Egg	71.3	61.5	81.4	74.2
23. Electrical resistance	23.1	8.	17.7	16.3
24. Electro-magnet	28.7	14.3	22.5	22.5
25. Enzyme	1.8	33.	29.2	21.9
26. Erosion	12.9	61.5	55.7	48.7
27. Equinox	37.	57.	25.6	37.6
28. Evolution	28.7	29.4	19.9	25.
29. Family tree	53.7	26.8	30.9	34.3
30. Fertility of soil	71.1	38.4	66.8	65.1
31. Fertilization of egg	25.9	49.	45.5	40.5
32. Flood plain	14.8	49.	17.7	28.7
33. Fossil	29.6	45.5	47.7	41.9
34. Gas diffusion	55.5	5.4	63.2	42.7
35. Germ plasm	4.6	2.7	8.2	5.8
36. Heat expansion	74.1	65.1	74.3	70.1
37. Ionization	1.8	3.6	3.	2.9
38. Isomer	2.8	0.0	6.6	4.1
39. Induced currents	5.5	3.6	13.2	9.3
40. Inertia	4.6	7.1	3.	4.9
41. Inoculation	40.7	8.9	22.9	23.1
42. Instinct	62.9	44.6	59.7	56.
43. Law of definite proportion	10.2	4.5	10.	9.7
44. Law of gravitation	51.8	13.4	31.4	30.6
45. Law of the lever	20.3	4.5	42.	26.4
46. Law of the pulley	21.3	3.6	44.2	26.4
47. Laws of fluid pressure	11.1	4.5	20.3	13.
48. Lines of magnetic force	17.6	7.1	7.	11.5
49. Mature topography	0.0	11.6	.8	3.9
50. Mendel's law of heredity	2.8	17.	1.7	6.
51. Metabolism	0.0	16.3	.8	4.1
52. Metamorphic rock	1.8	2.7	1.2	4.5

53. Migration.....	61.1	58.	67.7	61.8
54. Mimecry.....	14.8	15.2	11.9	13.6
55. Molecule.....	65.7	61.5	84.9	72.2
56. Momentum.....	25.9	18.7	22.9	22.3
57. Moraine.....	34.2	44.6	14.	7.4
58. Mutation.....	1.8	1.8	13.2	7.
59. Natural selection.....	20.3	16.3	16.2	14.3
60. Nebula.....	3.7	3.6	3.	2.7
61. Neap tide.....	3.7	2.7	6.	6.4
62. Nitrifying bacteria.....	8.3	16.9	18.1	17.2
63. Noneconformity of rock strata	4.6	3.6	2.1	3.7
64. Non-inheritance of acquired characters.....	14.8	15.2	9.2	11.5
65. Normal curve of variation.....	8.3	1.8	4.4	5.5
66. Orbit of the moon.....	28.7	30.3	21.2	26.4
67. Osmosis.....	2.8	33.1	42.	32.6
68. Oxidation.....	15.7	52.6	28.8	32.5
69. Photosynthesis.....	75.9	51.7	67.7	62.2
70. Parasitism.....	18.5	42.8	30.4	26.6
71. Planetesimal hypothesis.....	1.8	4.5	2.5	2.6
72. Plant or animal cell.....	30.5	52.6	48.6	55.8
73. Polarized light.....	7.4	4.5	6.6	6.8
74. Precession of the equinoxes.....	12.9	13.5	3.9	9.1
75. Precipitate.....	39.8	45.5	21.6	32.3
76. Pure line.....	5.5	2.7	11.8	7.8
77. Refraction of light.....	8.3	2.7	9.6	8.6
78. Regeneration of parts.....	11.1	22.3	7.8	11.9
79. Relation of frequency to pitch	0.0	3.6	3.	2.5
80. Reversion.....	15.7	8.9	24.8	17.5
81. Saturation.....	75.	63.3	73.9	8.6
82. Sedimentation.....	31.5	18.7	41.2	34.3
83. Solar system.....	24.1	72.3	26.9	39.6
84. Specialization of function	6.5	6.2	3.	4.5
85. Specific heat.....	11.1	7.1	20.3	14.4
86. Spectroscopic analysis.....	1.8	0.0	2.1	1.6
87. Spontaneous generation.....	3.7	5.4	7.	5.6
88. Stable equilibrium.....	4.6	8.9	4.8	6.
89. Star.....	62.9	59.	71.	69.8
90. Sterilization.....	75.9	41.9	80.6	66.1
91. Sub-atomic energy.....	1.8	.9	9.2	5.2
92. Surface tension.....	6.5	.9	4.4	4.5
93. Symbiosis.....	1.8	3.6	3.9	3.1
94. Synthetic sugar.....	1.8	2.7	3.	2.9
95. The ice age.....	31.5	23.2	41.2	34.1
96. Toxin.....	28.7	19.6	20.3	21.7
97. Tropism.....	2.8	0.0	2.5	1.8
98. Valence.....	2.8	1.8	3.	3.1
99. Variation.....	50.9	31.2	51.7	46.7
100. Vertebrate type.....	8.3	29.4	5.2	11.5

It is very evident that the test would be inappropriate below seventh grade for in this grade the average number of words correctly scored "E" is only 2.3. The seventh grade may be regarded then as the zero point for the test. Another important item appears from the first tabulation, namely, that students' estimates of their own ability increase in accuracy as they advance in the course. Among college students there is no scaling of their "E" grades, for they define or explain with certainty the terms they think they can explain. They know what they know

and are correspondingly cognizant of what they do not know. In the seventh grade, however, they mark "E" many terms they cannot explain satisfactorily, so that the number of words incorrectly defined is 78.5 per cent of those marked "E." This per cent decreases to zero among college Freshmen. There is also a fairly regular increase in the number of words correctly marked "E" from the seventh grade up through the college Sophomores.

There is a constant difference in the ability of boys and girls as revealed by the test; the girls mark fewer words "E" and more "F" than the boys. This is shown in the following tabulation:

TABLE III.

	Before correcting.		After correcting.	
	Boys.	Girls.	Boys.	Girls.
7th grade, Quincey.....	E 11.8	10.1	2.3	2.1
	F 17.6	20.2	27.	28.
8th grade, Quincey.....	E 16.	12.	6.3	3.3
	F 19.2	22.1	29.	31.
9th grade, Quincey High.....	E 27.4	22.5	20.4	15.
	F 24.	26.	30.8	33.7
10th grade, Quincey High.....	E 26.5	20.3	18.1	10.8
	F 27.6	34.	35.9	43.5
9th grade, U High.....	E 26.5	26.1	18.	17.5
	F 21.9	22.9	30.4	34.5
9th grade, Fenger High.....	E 23.6	18.9	20.	14.3
	F 17.5	19.9	21.	24.5
DeKalb Freshmen.....	E 36.3	34.2	no change	
	F 28.1	30.4	no change	
DeKalb Sophomores.....	E 51.2	41.6	no change	
	F 24.4	33.8	no change	

Including now thirty-eight (38) papers from High School, ninth grade, received from two other schools, Kalamazoo, Michigan, and Platteville, Wisconsin, there have been scored four hundred eighty-four (484) papers for this grade. The average uncorrected score is E, 24.4, F, 22.8, N, 52.8; corrected score E, 17.6, F, 27.2, N, 52.8.

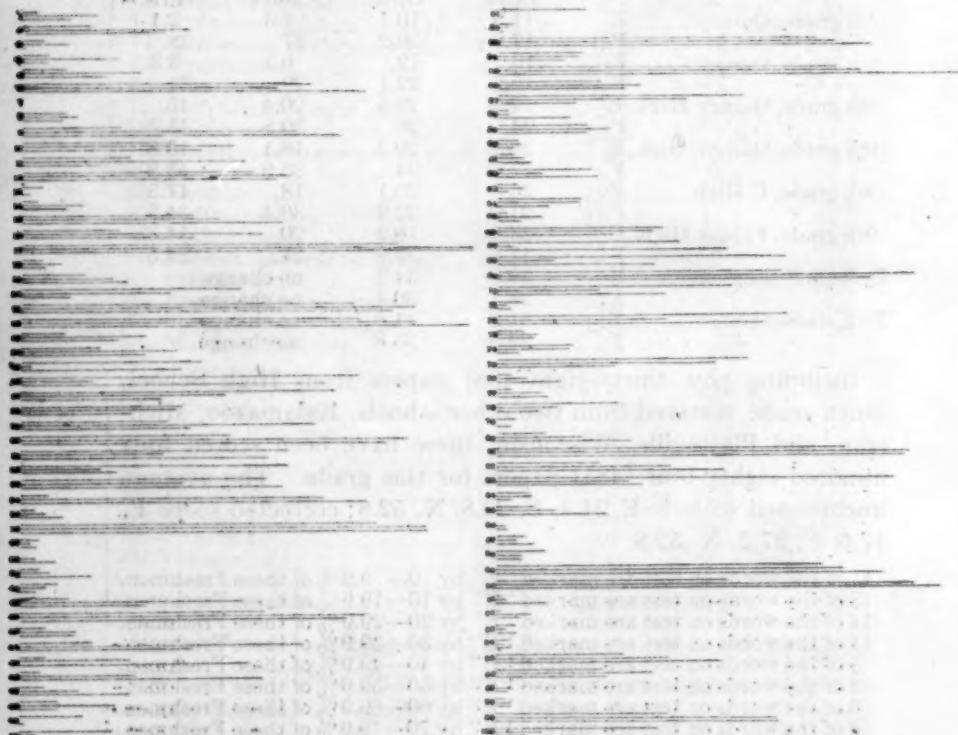
41 of the words on test are marked "E" by 0—9.9% of these Freshmen.
 13 of the words on test are marked "E" by 10—19.9% of these Freshmen.
 14 of the words on test are marked "E" by 20—29.9% of these Freshmen.
 11 of the words on test are marked "E" by 30—39.9% of these Freshmen.
 8 of the words on test are marked "E" by 40—49.9% of these Freshmen.
 3 of the words on test are marked "E" by 50—59.9% of these Freshmen.
 6 of the words on test are marked "E" by 60—69.9% of these Freshmen.
 4 of the words on test are marked "E" by 70—79.9% of these Freshmen.

100

The details of this statement appear in the fourth column of totals, in Table II above.

It is very evident then that more than half the words are marked "E" by less than twenty per cent of the pupils. It

seems advisable then to omit these words that are largely unknown and so reduce the list to fifty words. All words therefore marked "E" by fourteen per cent or less of the High School Freshmen are omitted from the revised list, and also three words scoring much higher but which are misleading as shown by the definitions. These three are animal society, egg, star. It was hoped the word "star" would suggest the notion that these bodies are distant suns, that "egg" would signify that speck of living substance from which the animal or plant develops after its fertilization, and that "animal society" would have an ecological significance, but most pupils think of a humane society in connection with animal society, food in connection with the



term "egg," and a twinkling object seen in the sky as a "star." The number of terms to be defined is increased to five, to get a better check on the student's estimate of his own ability. The revised test is as follows:*

Please put an E beside words and phrases (on the list below) that you can explain or define, an F beside those you have heard or read about, the meaning of which is not clear, and an N beside those that are new. Explain or define the first five you mark with an E, on the back of this sheet.

No.	Mark Here.		No.	Mark Here.
1		Adaptation	26	Inoculation
2		Atom	27	Instinet
3		Buoyancy	28	Law of gravitation
4		Candle power	29	Law of the lever
5		Center of gravity	30	Law of the pulley
6		Comet	31	Migration
7		Conduction	32	Molecule
8		Conservation of energy	33	Momentum
9		Dew point	34	Natural selection
10		Disease organisms	35	Nitrifying bacteria
11		Drowned valley	36	Orbit of the moon
12		Eclips	37	Osmosis
13		Electrical resistance	38	Oxidation
14		Electro-magnet	39	Photosynthesis
15		Enzyme	40	Parasitism
16		Erosion	41	Plant or animal cell
17		Equinox	42	Precipitate
18		Evolution	43	Reversion
19		Family tree	44	Sedimentation
20		Fertility of soil	45	Solar system
21		Fertilization of egg	46	Specific heat
22		Flood plain	47	Sterilization
23		Fossil	48	The ice age
24		Gas diffusion	49	Toxin
25		Heat expansion	50	Variation

Recounting the scores made by the four hundred eighty-four High School Freshmen on the fifty words retained in the revised test the average uncorrected score is found to be "E," 37.2, "F," 26.8, "N," 36.

*Copies of the revised test can be obtained from the author, The University of Chicago, The School of Education, for \$0.30 per hundred.

(Continued from page 80) **QUICKSILVER IN 1918.**

Although quicksilver is not a precious metal and, unlike iron and copper, is not one of the great basic materials of industry, nevertheless its unique position as the only metal that is liquid at ordinary temperatures and its varied and special applications in science and the arts give it peculiar interest. The report of the United States Geological Survey, Department of the Interior, on quicksilver in 1918, prepared by F. L. Ransome, not only gives the domestic production as a whole and by States for the year, but presents also the latest obtainable figures for the world's production and contains information on the quantity and character of ore treated, methods of reduction, prices, imports and exports, and uses of quicksilver. The report also contains notes on the operations at individual mines and a table wherein are listed most of the quicksilver mines of the United States with notes on the character of deposit, workings, reduction equipment, and total output of each mine.

SHIPMENTS IN 1918 OF WATER WHEELS MANUFACTURED IN THE UNITED STATES.

As an index of industrial development, the sale of water wheels has some value. The following table, based on returns received by the United States Geological Survey, Department of the Interior, from practically all manufacturers of turbines and impulse wheels in the United States, indicates by States the aggregate capacity of water wheels shipped in 1918. The State indicated is that in which the wheels are intended to be installed. No information is available in regard to the importation of water wheels. In view of the war conditions in 1918 it may probably be safely assumed that there were no importations of water wheels during the year. It is of interest to note that the total horse-power of water wheels shipped during 1918 for the three States of Georgia, South Carolina, and Tennessee is almost equal to that shipped to all the other States.

State.	Horse-power.	State.	Horse-power.
Alabama	1,650	New Jersey	565
Arizona	1,049	New Mexico	93
California	5,780	New York	50,851
Colorado	297	North Carolina	2,826
Connecticut	922	Ohio	245
Delaware	247	Oregon	5
Georgia	21,107	Pennsylvania	921
Idaho	7,924	Rhode Island	1,330
Illinois	4,810	South Carolina	108,435
Iowa	45	Tennessee	55,373
Kansas	1,200	Utah	9,134
Kentucky	37	Vermont	3,962
Louisiana	95	Virginia	806
Maine	9,231	Washington	5,565
Maryland	548	West Virginia	3,632
Massachusetts	23,417	Wisconsin	10,187
Michigan	16,462		
Minnesota	29,621	Exported	387,843
Montana	205		108,376
Nebraska	836		
Nevada	220		496,219
New Hampshire	8,210		

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for October; *Brooklyn Botanic Garden*, Brooklyn, N. Y. \$5.00 per year. 60 cents a copy. "Venation and Senescence of Polyembryonic Citrus Plants," M. R. Ensign; "A Study of Some Factors in the Chemical Stimulation of the Growth of *Aspergillus Niger*," Robert A. Steinberg.

Geographical Review for December; *Broadway at 156th Street, New York City*. \$5.00 per year, 50 cents a copy. "German Colonization in Eastern Europe," Jean Brunhes and Camille Vallaux, (1 map); "The Western Maracaibo Lowland, Venezuela," Theodoor de Booy, (1 insert map in color, 13 photos); "A Combined Map and Panorama for Orientation from Lookout Stations," Emanuel Fritz, (1 insert plate, 2 photos); "The Indians of the Great Lakes Region and Their Environment," A. E. Parkins.

Journal of Geography for November; *Broadway at 156th Street, New York City*; \$1.00 per year, 15 cents a copy. "Southeastern Utah: A Study of an Arid Region," Malcolm Rutherford Thorpe, "Status of Geography in Normal Schools of the Far West," Clyde E. Cooper; "Our Geography Correspondence," Jehiel S. Davis.

Literary Digest for December 6; *New York City*; 10 cents a copy. "Are the Coal Operators Profiteering?" "How to Save the Treaty;" "Silver Power '16 to '1;" "Europe's Money in a Sinking Well;" "The Farmer Will Have His Own Now;" "America's Abandonment of Europe." For December 13, "Our New Grievance Against Mexico;" "The President on Labor Unrest;" "Down to Facts in the Coal Fight;" "Ellis Island Gates Ajar;" "The New Labor Party."

National Geographic Magazine for December; *Washington, D. C.*; \$3.00 per year, 35 cents a copy. "The Romance of Military Insignia," 27 illustrations, Robert E. Wyllie; "American Decorations and Insignia of Honor and Service," 124 illustrations; "Celebrating Christmas on the Meuse," 5 illustrations, Clifton Lisle; "The Camel of the Frozen North," 19 illustrations, Carl J. Lomen.

Photo-Era for November, *Boston, Mass.*; \$2.00 per year, 20 cents a copy. "Gloucester the Picturesque," Herbert B. Turner; "Improving a Snapshot," William S. Davis; "The Ethics of Specimen-Prints," The British Journal; "Cobweb-Photography," Beatrice B. Bell; "The Ship Mayflower," Wilfred A. French; "The Secret of Beautiful Photography," Ward Muir.

Popular Astronomy, for December; *Northfield, Minn.*, \$4.00 per year. "The 100-Inch Hooker Telescope of the Mount Wilson Observatory," with Plate XLIX, George E. Hale; "The Reform of the Julian Calendar," Roscoe Lamont; "Motion of a Particle About a Circular Disc" F. J. B. Cordeiro; "An Intensely Red Variable Star," with Plate L, J. A. Parkhurst; "The Flash Spectrum of June 8, 1918," concluded, H. C. Wilson; "Twenty-third Meeting of the American Astronomical Society," continued, with Plates LI and LII.

School Review, for December; *University of Chicago Press*, \$1.50 per year, 20 cents a copy. "Supervisory Leadership on the Part of the High-School Principal," Franklin Bobbitt; "The Measurement of Physics Information" J. Crosby Chapman; "Character and Value of Standardized Tests in History," Earle Underwood Rugg.

Scientific Monthly, for December; *Garrison, N. Y.*, \$5.00 per year, 50 cents a copy. "The Mechanism of Evolution in the Light of Heredity and Development," Edwin G. Conklin; "Our Universe of Stars," Eric Dooddle; "Individuality in Research," R. D. Carmichael; "The Romance and the Tragedy of Sneezing," Dr. Wilson D. Wallis; "Physiological Inertia and Physiological Momentum," D. F. Harris; "The Origins of Civilization," James H. Breasted; "Natural Death and the Duration of Life," Dr. Jacques Loeb.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution as on the following pages.

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.

SOLUTION OF PROBLEMS.

621. Proposed by Louis Sklar, Philadelphia, Pa. (Corrected version.)

Solve:

$$\begin{aligned}y^2 - z^2 + 2xy + 2xz &= 5 & (1) \\x^2 - y^2 + 2yz - 2xz &= -5 & (2) \\2x + y - z &= 1 & (3)\end{aligned}$$

I. Solution by Walter R. Warne, State College, Pa.

From (1),

$$(y+z)(2x+y-z) = 5 \quad (4)$$

Dividing by (3),

$$(y+z) = 5 \quad (5)$$

From (2),

$$(x-y)(x+y-2z) = -5 \quad (6)$$

(3) + (5) gives

$$(x+y) = 3 \quad (7)$$

From (5), (6), (7),

$$(2x-3)(2x+1) = 5 \quad (8)$$

Obviously, now, $x = 2, -1; y = 1, 4; z = 4, 1$ which, as paired, check.

II. Solution by M. G. Schucker, Pittsburgh, Pa.

Arranging terms to show the difference of two squares,

(1) becomes

$$(x^2 + 2xy + y^2) - (x^2 - 2xz + z^2) = 5. \quad (4)$$

(2) becomes

$$(x^2 - 2xz + z^2) - (y^2 - 2yz + z^2) = -5. \quad (5)$$

(3) may be written

$$(x+y) + (x-z) = 1. \quad (6)$$

Dividing (4) by (6)

$$(x+y) - (x-z) = 5 \quad (7)$$

and $x+y = 3, x-z = -2, y+z = 5, y-z = \pm 3$ $x = -1 \text{ or } 2; y = 4 \text{ or } 1; z = 1 \text{ or } 4.$ [The following solution refers to the incorrect version of the problem which had $2yz$ instead of $2xz$ in equation (1).—Editor.]

III. Solution by A. Pelletier, Ecole Polytechnique, Montreal, Can.

Eliminating y and z from the system we obtain the equation

$$8x^3 - 43x^2 + 36x + 52 = 0.$$

By Sturm's theorem we find that it has three real roots, two positive and one negative; the positive are between 2 and 3, 3 and 4; the negative is between 0 and -1. By Horner's method, I found $x' = 3.661 -$, $x'' = 2.442 -$, $x''' = -.727 +$; then we easily get the corresponding values of y and z . I found $y' = 3.252 -$, $y'' = -4.616 +$, $y''' = 2.739$ and $z' = 0.573$, $z'' = -.733 +$, $z''' = .285$.

Solutions were also received from N. BAROTZ, R. C. STALEY, A. PELLETIER (corrected version). One unsigned solution was received.

622. Proposed by A. Pelletier, Montreal, Can.

For what values of x will $x^2 + x$ be a square? Give a systematic procedure to derive these values.

I. Solution by R. T. McGregor, Elk Grove, Cal.

Let

$$x^2 + x = (x-a)^2.$$

From this equation

$$x = a^2/(1+2a),$$

and by assigning at pleasure different values of a , we obtain the required values of x .

II. S. H. Parsons, Paris, Ontario, notes at the close of a solution similar to the above that for integral values of a , the series of values of x is
 $-3^2/-5, -2^2/-3, -1^2/-1, 0^2/1, 1^2/3, 2^2/5, 3^2/7,$

III. The Proposer submitted the following statement without indicating method used to obtain it.

The identity

$$[(k - \frac{1}{2})^2/2k]^2 + (k - \frac{1}{2})/2k = [(k^2 - \frac{1}{4})/2k]^2$$

solves at once the problem. We make $x = (k - \frac{1}{2})^2/2k$, in which k is any rational number.

IV. Solution by N. Barotz, New York City.

Let $x = a/n$ (where a and n are any rational numbers.)

then: $a^2/n^2 + a/n$ must be a square.

or: $(a^2 + an)/n^2$ must be a square.

This will be true if $a^2 + an$ is a square.

Let: $a^2 + an = m^2$ (m is any rational number.)

then $n = (m^2 - a^2)/a$

Therefore: $a/n = a^2/(m^2 - a^2) = x$.

To find values of x , substitute values for a and m in the above formula. Unless a or m are irrational, $x^2 + x$ will be a square.

V. Remarks by the Editor.

Solutions I. and III. are of the same type, the parameters a and k being connected by the relation $a = k - \frac{1}{2}$, or $a = (\frac{1}{2} - k)/2k$. Neither solution will hold for all rational values of the parameter as indicated by the author. I. is impossible when $0 > a > -1$ and III. when $\frac{1}{2} > k > -\frac{1}{2}$. Similarly the solution of IV. does not hold if $0 > a^2/(m^2 - a^2) > -1$, or if a and m are connected by the relation $a^2(1-\epsilon) + m^2 = 0$, where $0 < \epsilon < 1$. The graph of $f(x) = x^2 + x$ shows that these values mentioned correspond to that value of the function which is negative (or below the X-axis).

One incorrect solution was received.

623. Proposed by C. E. Githens, Wheeling, W. Va.

The three roots of a cubic equation are $\cos 20^\circ$, $-\cos 40^\circ$ and $-\cos 80^\circ$. Required the equation.

Solution by A. Pelletier, Montreal, Can.

Let $x^3 + ax^2 + bx + c = 0$ be the required equation, in which a , b , c are to be determined. If r_1 , r_2 , r_3 are the roots, we know that

$$a = -(r_1 + r_2 + r_3), \quad b = r_1r_2 + r_2r_3 + r_3r_1, \quad c = -r_1r_2r_3,$$

hence, $a = \cos 40^\circ + \cos 80^\circ - \cos 20^\circ = 2\cos 60^\circ \cos 20^\circ - \cos 20^\circ = 0$;

$$b = -\cos 20^\circ \cos 40^\circ + \cos 40^\circ \cos 80^\circ - \cos 20^\circ \cos 80^\circ = -(\cos 60^\circ + \cos 20^\circ)/2 + (\cos 120^\circ + \cos 40^\circ)/2 - (\cos 100^\circ + \cos 60^\circ)/2$$

$$= -3/4 + (\cos 40^\circ + \cos 80^\circ - \cos 20^\circ)/2$$

$$= -3/4;$$

$$c = -\cos 20^\circ \cos 40^\circ \cos 80^\circ = -\cos 20^\circ/2(\cos 120^\circ + \cos 40^\circ)$$

$$= -\cos 20^\circ/2(2\cos^2 20^\circ - 3/2) = -1/4(4\cos^2 20^\circ - 3\cos 20^\circ) = -1/4\cos 60^\circ = -1/8.$$

Therefore, the required equation is $x^3 - 3/4x - 1/8 = 0$.

Solutions were received from N. BAROTZ, M. G. SCHUCKER and the PROPOSER.

624. Proposed by J. Carl Kamplain, Student, Crane Junior College, Chicago.

To determine a point such that its distance from the vertices of a given triangle are inversely proportional to the sides of the triangle opposite the respective vertices.

I. Solution by A. Pelletier, Montreal, Can.

Let ABC be the given triangle, and h_a , h_b , h_c its three heights. Find two points M and N dividing BC internally and externally in the ratio $h_b : h_c$, and describe the circle having MN for diameter. Likewise, take M' and N' dividing BA in the ratio $h_b : h_a$, and describe the circle M'N'. The two points of intersection of the circles, P and P', answer the question.

For, $PB/PC = h_b/h_c$, and $PB/PA = h_b/h_a$, hence,

$$PA : PB : PC = h_a : h_b : h_c$$

But, $h_a : h_b : h_c = 1/a : 1/b : 1/c$, therefore,

$$PA : PB : PC = 1/a : 1/b : 1/c.$$

II. Solution by N. Barotz, New York City.

Construction:

(ABC is the given triangle and O the required point.) Construct a circle with BC as the diameter. Draw AD bisecting angle A. Let E be the mid-point of the semi-circle outside the triangle. Draw line EDF intersecting the circle in F. Draw the circle ADF. Duplicate this construction beginning with the side AC. The intersection of the resulting circle with the circle ADF, if within the triangle, is the required point, O.

To prove the construction it should be proved that: The locus of a point the ratio of whose distances from two given points is constant, is a circle. This can easily be proved by analytic geometry.

Since AD bisects angle A, and since FD bisects angle BFC, $AB : AC = FB : FC = BD : DC$. Therefore the circle determined by the points A, F, and D, is the locus of all points, the ratio of whose distances from B and C is a constant equal to AB/AC . In a similar way, the second determined circle is the locus of all points whose distances from C and A are in the ratio BC/BA . Therefore the intersection of both circles, O, is the point so situated that $OB : OC = AB : AC$ and $OC : OA = BC : BA$. Or, OB, OC and OA are inversely proportional to AC, AB and BC.

625. Proposed by Clifford N. Mills, Brookings, So. Dak.

If from the vertices of a triangle ABC, three straight lines, AA', BB', CC', are drawn to the opposite sides (or these sides produced), each equal to a given line, l, and from any point O within the triangle, Oa , Ob , Oc , are drawn parallel respectively to AA', BB', CC', and terminating in the same sides, then

$$Oa + Ob + Oc = l.$$

Solution by A. Pelletier.

Join AO, BO, CO, and produce to meet BC at M, AC at N, and AB at P. We have

$$Oa/l = OM/AM = OBC/ABC;$$

$$Ob/l = ON/BN = AOC/ABC;$$

$$Oc/l = OP/CP = ABO/ABC;$$

hence, $(Oa + Ob + Oc)/l = (OBC + AOC + ABO)/ABC = 1$

$$\text{Therefore, } Oa + Ob + Oc = l.$$

609. Proposed by Harris F. MacNeish, New York City.

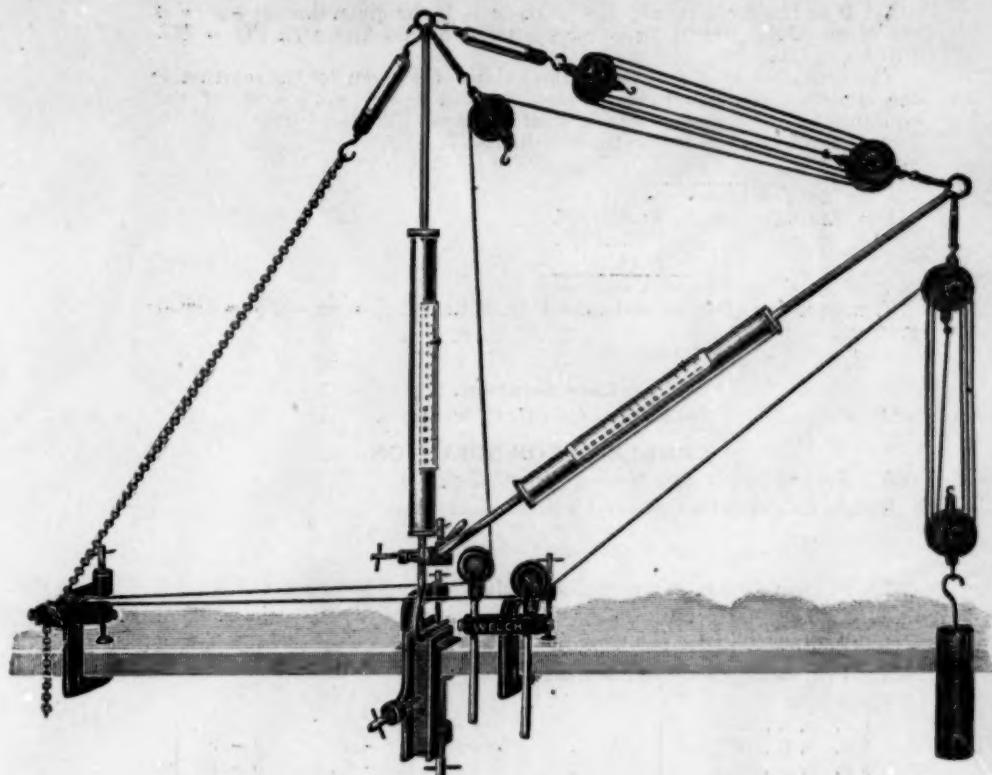
Through a given point draw a straight line cutting a given straight line and a given circle such that the part of the line between the point and the given line may be equal to the part within the given circle.

[This was proposed in April and no synthetic method of solution has been received. The following solution by means of analytic geometry seems to be the simplest obtainable and shows that the solution of a fourth degree equation is necessary to obtain the necessary value to construct the line.—Editor.]

A Sign of Quality

QUALITY
WELCH
SERVICE

A Mark of Service



COMPLETE DERRICK OUTFIT

Made Up From Standard Pieces

MAKE YOUR SCIENCE TEACHING MORE PRACTICAL AND EFFECTIVE

Quality in apparatus is your first requirement, and Service which helps you in selecting your equipment is what you appreciate most.

Write us telling us what text you use and we will send you our catalogs and lists which will give you an example of the service of our experts.

NEW CATALOGS just off the press in *Agriculture, Biology, Physics and Chemistry, Wireless Apparatus, Text Book Lists, State Lists, Bulletins of Special Pieces, etc.*

W. M. Welch Scientific Company

*Manufacturers, Importers and Exporters
of Scientific Apparatus*

1516 Orleans Street

Chicago, Ill., U. S. A.

Please mention School Science and Mathematics when answering advertisements.

Solution by N. P. Pandya, Amreli (Kathiawad), India.

Let P be the given point, (h, k) ; QL ($y = l$) the given line; $x^2 + y^2 = a^2$ the given circle; PQFG ($y = mx + c$) the required line with $PQ = FG$. $PL (= p) \perp QL$.

The ordinates of F and G are the values of y given by the solution of the simultaneous equations $y = mx + c$ and $x^2 + y^2 = a^2$, i. e., of the equation $(y - c)^2 + y^2 m^2 = a^2 m^2$, i. e., of $y^2(1 + m^2) - 2cy + c^2 - a^2 m^2 = 0$

\therefore the difference between these ordinates is

$$\begin{aligned} & [2\sqrt{c^2 - (1+m^2)(c^2 - a^2 m^2)}] / (1+m^2) \\ & = [2m\sqrt{a^2(1+m^2) - c^2}] / (1+m^2) \end{aligned}$$

$$\begin{aligned} \text{But this difference} &= FG \sin PQL \\ &= PQ \sin PQL \\ &= p \end{aligned}$$

$$\therefore p(1+m^2) = 2m\sqrt{a^2(1+m^2) - c^2}.$$

This equation gives m ; and since P (h, k) lies on $y = mx + c$, $k = hm + c$ gives c .

$\therefore y = mx + c$ is determined.

Late Solution.

A solution to 612 was received from G. C. Williams.

PROBLEMS FOR SOLUTION.

636. Proposed by Walter Warne, State College, Pa.

Obtain all the values of x and y in the equations

$$\begin{aligned} x+y &= 14-y^2, \\ x^3y^2+xy^2+xy^3 &= 600-x^2y^4-2x^3y^2 \end{aligned}$$

637. Proposed by A. Pelletier, Ecole Polytechnique, Montreal, Can.

A, B, C are three numbers having, respectively, α , β , γ digits. Find the number of digits in the expression $(AB/C)^n$.

638. Proposed by Walter R. Warne.

Show that

$$\begin{vmatrix} x, & y, & z, & w \\ a, & b, & c, & d \\ d, & e, & b, & a \\ w, & z, & y, & x \end{vmatrix} = \begin{vmatrix} (x+w), & & (y+z) \\ (a+d), & & (b+c) \end{vmatrix} \cdot \begin{vmatrix} (x-w), & & (y-z) \\ (a-d), & & (b-c) \end{vmatrix}$$

639. Proposed by N. P. Pandya, Amreli, Kathiawad, India.

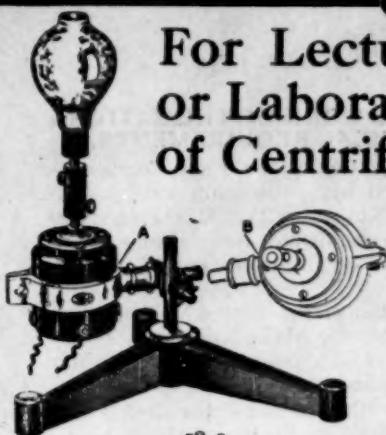
A quadrilateral ABCD has $AB : BC : CD : DA = 1 : 2 : 3 : 4$. On DA a part, DE, is cut off equal to 3AB. Find the condition that in the triangle BCE, $CB = CE$.

640. Proposed by Walter R. Warne.

If $\alpha + \beta + \gamma + \delta = 360^\circ$, change the expression $\cot(\alpha/2) + \cot(\beta/2) + \cot(\gamma/2) + \cot(\delta/2)$ into a product in which δ is lacking.

USED FOR COLORING GLASS.

The production of selenium in 1918 was 103,694 pounds, valued at \$206,540, an increase of 162 per cent in quantity and 195 per cent in value as compared with figures for the previous year. Of the quantity sold during 1918 about 60 per cent was used as a coloring and deoxidizing agent by the glass industry, according to the United States Geological Survey, Department of the Interior.



58-9

**The Waverley-Electric
Specifications**

Support—Standard Tripod.
Yoke—Cast Aluminum.
Housing—Enamelled Iron.
Motor—6,000 R. P. M.
Mica Insulation. Self-Adjusting Brushes.
Ball-Bearing Shaft.
Current—D. C., A. C., or Dry Cells.
Chuck—Universal.

You Need This Waverley Electric—
A Whirling Machine and Centrifuge Combined.

As a whirling machine the Waverley-Electric takes a Centrifugal Globe (as illustrated), or Double Hoops, Centrifugal Balls, and other accessories.

A Centrifuge Head converts the Waverley-Electric into a powerful centrifuge that may be used with efficacy for the analysis of milk, urine, blood, or other liquids.

The specially designed, ball-bearing motor is mounted and balanced to operate in vertical or horizontal position. Consequently its general utility includes the rotation of Savart's Wheels, Siren Discs, Newton's Color Discs and the like.

58-9 The Waverley-Electric, including Support, Yoke, Motor and Chuck..... \$19.00

58-9a Waverley Centrifuge Head, four-arm. 3.75

Cambridge Botanical Supply Company
LABORATORY EQUIPMENT—ALL SCIENCES

1-9 Lexington Street

1884-1919

Waverley, Mass.

DEVELOPMENT OF GROUP INTELLIGENCE TESTS.

During the war great impetus was given to the development of general mental ability or intelligence tests by their use in the examination of army recruits. A very efficient instrument for intelligence examinations exists in the Stanford revision of the Binet Scale, but for general application a test which can be given to entire groups simultaneously and scored rapidly is necessary. The army tests were designed for the adult level. Dr. F. N. Freeman and Dr. H. O. Rugg have been at work on a group test which is intended particularly for the junior and senior high school students. Two parallel forms of the test of approximately equal difficulty are approaching final form. They are printed and ready for distribution, the University of Chicago Press, at a moderate price, three cents each. This price includes instruction and scoring sheets and blank forms for the tabulation of results.

THE POTTERY INDUSTRY IN 1918.

The publication of a report on the pottery industry in 1918 has just been announced by the United States Geological Survey, Department of the Interior. This report contains a summary of the status of this increasingly important industry under war conditions, with its restrictions and handicaps, which were many and oftentimes onerous. It also contains statistics showing the growth of the industry during ten years, the production of pottery by States and kinds of ware, and the imports and exports of pottery. An interesting feature of the report is a description of the White House state dining service made and installed during the year. Especial interest attaches to this service, as it is the first American-made state service used in the White House and is known as the "President Wilson design" because of the President's interest in the design and his suggestions concerning it. A copy of this report may be obtained by applying to the Director, United States Geological Survey, Washington, D. C.

NOTES AND NEWS REGARDING THE WORK OF THE NATIONAL COMMITTEE ON MATHEMATICAL REQUIREMENTS.

A preliminary report on "The Reorganization of the First Courses in Secondary School Mathematics," prepared by a sub-committee, which was authorized to publish it, was issued on November 25. It is being made the basis of discussion by organizations, committees, local groups, etc., throughout the country. Over thirty such organizations are at present at work on this report.

The whole of the meeting of the Association of Teachers of Mathematics in the Middle States and Maryland, in Philadelphia on November 29 was devoted to the discussion of this report; it had a prominent place on the program of the Central Association of Science and Mathematics Teachers in Chicago on November 28 and 29, and at the meeting of the Association of Teachers of Mathematics in New England, in Boston on December 6.

Committees representing organizations in the following states are actively cooperating with the National Committee: Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Wisconsin, Iowa, North Dakota, Missouri and Texas.

Local groups or clubs are studying the report in Boston, Springfield, (Mass.), Providence, New Haven, New York City, Washington, Baltimore, Cincinnati, Columbus, (Ohio), Terre Haute, Chicago, St. Louis, St. Paul, Minneapolis and in several smaller cities.

Meetings in addition to those previously announced at which the work of the National Committee will be discussed are as follows: Mathematical Association of America in St. Louis, December 29, and in New York, January 2; Ohio State Teachers Association, Columbus, December 30; Pennsylvania State Educational Association, Philadelphia, December 30; Association of Teachers of Mathematics in the Middle States and Maryland, Southern Section, Baltimore, December 13, Syracuse Section, Syracuse, New York, December 30.

The next meeting of the National Committee will occur in New York City on December 30. The principal items on the program for this meeting are the consideration of the report on "The Reorganization of the First Courses in Secondary School Mathematics," the report on "The Valid Aims and Purposes of the Study of Mathematics" and the proposed revision of college entrance requirements.

The United States Bureau of Education has offered to publish the reports of the National Committee in the form of leaflets or bulletins.

A Mathematics Section of the West Virginia State Teachers Association was organized in Fairmont on November 28. Professor John Eiesland of the University of West Virginia was elected Chairman of the newly formed section. Professor C. N. Moore spoke in behalf of the work of the National Committee.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. School examinations of all sorts are wanted. If you have run across anything queer, be sure to send it in.

Among the New Books

Schorling and Reeve's General Mathematics

For the ninth grade. A course in the fundamental facts of general mathematics in which the authors make functional thinking the organizing and unifying principle.

Wentworth-Smith's Higher Arithmetic

For high schools and normal schools. It offers the arithmetic that every citizen should know. It teaches the worth of thrift and investment.

Test and McLaughlin's Notes on Qualitative Analysis

Prepared especially for students requiring a brief course. It gives a broader knowledge of general chemistry through the exposition of the underlying principles of Ionic Theory and Mass Law.



GINN AND COMPANY

Boston
Atlanta

New York
Dallas

Chicago
Columbus

London
San Francisco

QUESTIONS AND PROBLEMS FOR SOLUTION.

(Please send answers to the following questions here repeated.)

307. *Proposed by G. Ross Robertson, Riverside, Cal.*

Why is the rust, or tarnish, or corroded surface of common lead, grey or black? (The oxides of lead are yellow, red, or brown.)

317. *Proposed by J. C. Packard, Brookline, Mass.*

An automobile, weighing with load 1,000 lbs., while running at the rate of 5 miles an hour collides with a telegraph pole. The fender is crushed in about 2 inches. How heavy a blow did the auto deliver?

[Query: Is this the piledriver problem in another form?—EDITOR.]

330. *The fly and spider problem. (See November, 1919.)*

(Only one correct solution has been received.)

335. *Proposed for Solution by W. L. Malone, Tacoma, Wash.*

"If a man can jump 3 feet high on the earth, how high could he jump on the moon, where g is $\frac{1}{6}$ as much?"

(First Course in Physics, page 94, Revised Edition. Millikan and Gale.)

SOLUTIONS AND ANSWERS.

328. *Proposed to boys in The Warner & Swasey Apprentice School by Mr. Worcester R. Warner.*

The Panama Canal Locks at Gatun are in a series of three, each 1,000 feet long and 110 feet wide. Each of the three locks raises or lowers a ship 28 feet.

Gatun Lake is, therefore, 84 feet above sea level.

It is desired, first, to determine the quantity of water required to take each ship—one at a time—from the Caribbean Sea into Gatun Lake; and, second, the quantity of water required to return each ship—one at a time—from the lake to the Caribbean Sea again.

Answers are required in tons, computed by the following formula:

Cubic feet of water X .028 = tons.

Let us suppose a ship has just come down from Gatun Lake to the Caribbean Sea. The ships "A" and "B" are waiting to be taken from the sea to Gatun Lake, and back to the sea again, "B" to follow "A" in each direction.

Question 1: How much water must be taken from the lake to take "A" from the sea into the lake?

Question 2: How much water must be taken from the lake to take "B" from the sea into the lake?

Question 3: How much water must be taken from the lake to take "A" from the lake to the sea?

Question 4: How much water must be taken from the lake to take "B" from the lake to the sea?

The displacement of these ships is 35,000 tons each.

Another solution to 328. What is the matter with it?

Question 1: A to lake from sea. $(3 \times 86,240) + 35,000 = 293,-$ } up.
720 tons.

Question 2: B to lake from sea. $293,720 - (2 \times 86,240) = 121,-$ } up.
240 tons.

Question 3: A from lake to sea. None taken from lake.

Question 4: B from lake to sea. $86,240 - 35,000 = 51,240$ } Down.
tons.

More answers to 328.

A—up 188,720 tons.

B—up 86,240 tons.

A—down none.

B—down 51,240 tons.

EXAMINATION PAPER.

Brown University

EXAMINATION FOR ADMISSION.

Physics.

September 21, 1918.

Omit three questions. The reasoning by which numerical results are obtained must be clearly stated.

1. State Archimedes' Principle. Describe two methods by which it may be utilized to find the density of a body.

2. A stone attached to the end of a string two feet long is whirled in a vertical circle at a uniform rate of ten revolutions per second. Is the velocity of the stone constant or accelerated? If the string breaks when the stone is at the top of the circular path, what is the direction and magnitude of the velocity of the stone?

3. If the center of the circular path in problem two is four feet above a level road, how far will the stone travel before it strikes the ground? Acceleration due to gravity is 32.2 feet per second.

4. A base ball pitcher delivers the ball in one second with a velocity of 100 feet per second. If the ball weighs seven ounces, how much power does he develop? One horse-power is equivalent to 550 foot-pounds per second.

5. What holds the ink on a common writing pen? Why does the pen not work well when handled with the fingers before it is dipped in ink? Why will it not mark well on glazed paper or on greasy paper?

6. Explain some method by which a clock pendulum can be compensated for changes in temperature so that the clock will keep correct time at any ordinary temperature.

7. A small compass is placed under an electric light wire suspended horizontally in the magnetic meridian. The north pole of the compass points west. What is the direction of the current in the wire?

8. A man standing on a corner noticed that his shadows cast by two arc lights appeared equally dark. One of the lights was 50 feet from the man and the other was 100 feet from him. What was the relative intensity of the two lights? Which was the more intense?

9. An electric water heater operates on five amperes when connected to a 100 volt circuit. If the price of electric power is ten cents per kilowatt hour, what will it cost to heat one liter of water from twenty degrees centigrade to the boiling point? How long will it take? One calorie is equivalent to 4.2 watt-seconds.

**VISUAL INSTRUCTION
WITH
SPENCER DELINEASCOPE
MODEL 3**

is made perfect because it is an IDEAL STEREOPTICON for both lantern slides and opaque objects, such as pictures, post-cards, reading matter and objects of all kinds dead and alive.

IDEAL, because it embodies basic ideas (patented) possessed by no other. Example: Mechanical means of handling the slides, which does away with the antiquated lantern-slide holder and at the same time gives a "dissolving effect" on the screen unattained with other outfits except by using two stereopticons, one above the other.

One Spencer Delineascope does it.



Spencer Delineascope Model 3 for both lantern slides and opaque objects. 1,000 Watt Mazda bulb illuminant.
Price, \$150.00



SPENCER LENS COMPANY
Buffalo, New York

Manufacturers of Microscopes, Microtomes, Delineasopes, Optical Glass, Scientific Apparatus, Etc.



Kalato Laboratory Filter Paper

Suitable for all analytical purposes other than those requiring the use of a paper extracted with Hydrochloric and Hydrofluoric acid. Filters rapidly and retains the finest precipitates. Weight of ash 3 in. circle, 0.012 gm. Sample sent on request.

Complete Supplies for Chemistry, Biology and Physics

Let us quote prices on your next list of requirements

THE KAUFFMAN - LATTIMER CO.

44-46 East Chestnut Street
COLUMBUS, OHIO

BOOK REVIEW.

Qualitative Analysis, by J. O. Frank, Department of Chemistry, Wisconsin State Normal School, Oshkosh, Wis. Second Edition. Pp. 36, 14.8x 22.2x3 cm. Flexible board binding. 1919. 50c wholesale; with chart 60c. Published by the author, at Oshkosh, Wis.

An inexpensive laboratory guide, understandable to the student in the High School and covering only the fundamentals of qualitative analysis. The outlines of the work only are given in the manual, it being understood that the explanation of the procedure will be given later by the teacher or larger works referred to for equations and the theory. The author believes in having his pupils learn things by doing them and therefore puts them to work in the laboratory first. As he himself says, "The work first; theories, laws, precautions, explanations, etc., afterwards." A chart giving a suggestive outline for systematic analysis of salts may be had with the manual for ten cents extra. Pages 10 to 18 give valuable "Notes on the separation and identification of the metals." These are all the book affords in the way of explaining the why of the processes. The author also leaves it to the teacher to treat the subject from the viewpoint of the ionic theory, specifically suggesting in the preface, however, that this should be done.

F. B. W.

BOOKS RECEIVED.

Applied Science for Wood-Workers, by William H. Dooley, Principal of New York Textile School. Pages x+457. 13.5x19 cm. Cloth. 1919. The Ronald Press Company, New York.

An Introductory Course in Quantitative Chemical Analysis, by George McPhail Smith, University of Illinois. Pages xi+206. 15x22 cm. Cloth. 1919. The Macmillan Company, New York.

The Principles of Agriculture, by John H. Gehrs, Normal School, Cape Girardeau, Mo. Pages x+594. 13.5x19 cm. Cloth. 1919. \$2.25. The Macmillan Company, New York.

Exercises in Chemistry, by William A. Noyes, Director of the Chemical Laboratory, and B. S. Hopkins, University of Illinois. Pages vi+131. 12.5x19 cm. Paper, 1919. Henry Holt and Company, New York.

Number by Development, Parts I and II, by John C. Gray, Superintendent of Schools, Chicopee, Mass. Part I. Pages xxii+486. 13.5x19 cm. Cloth. 1919. Part II, xx+514. 13.5x19 cm. Cloth, 1919. J. B. Lippincott Company, Philadelphia.

Teaching Home Economics, by Anna M. Cooley, Cora M. Winchell, Wilhemina H. Spohr, and Josephine A. Marshall. Teachers College, Columbia University. Pages xii+555. 13.5x20 cm. Cloth. 1919. \$1.80. The Macmillan Company, New York.

College Textbook of Chemistry, by William A. Noyes, Director of the Chemical Laboratory. The University of Illinois. Pages vii+370. 13.5x19.5 cm. Cloth. 1919. Henry Holt and Company, New York.

Applied Science for Metal-Workers, by William H. Dooley, Principal of New York Textile School. Pages x+479. 13.5x19 cm. Cloth. 1919. The Ronald Press Company, New York.

TIN MINING IN SEWARD PENINSULA.

Stream tin, a form of cassiterite, the most valuable ore of tin, has been found in many streams in Alaska, and lodes of cassiterite have been prospected and mined at several places in the Territory. An account of the tin deposits and tin mining in Seward Peninsula is given by G. L. Harrington in Bulletin 692-G, which contains descriptions of the lodes and placers mined.